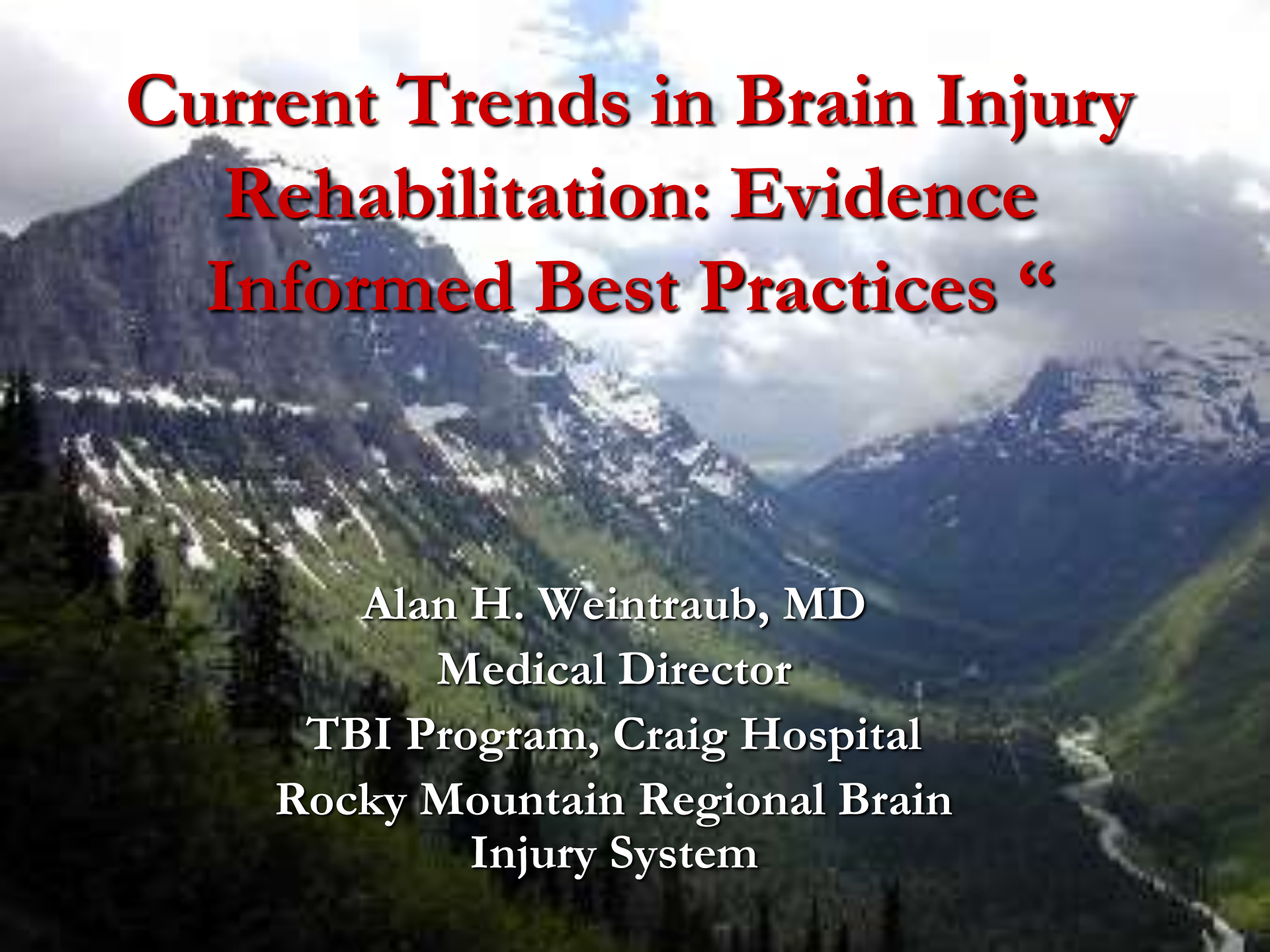
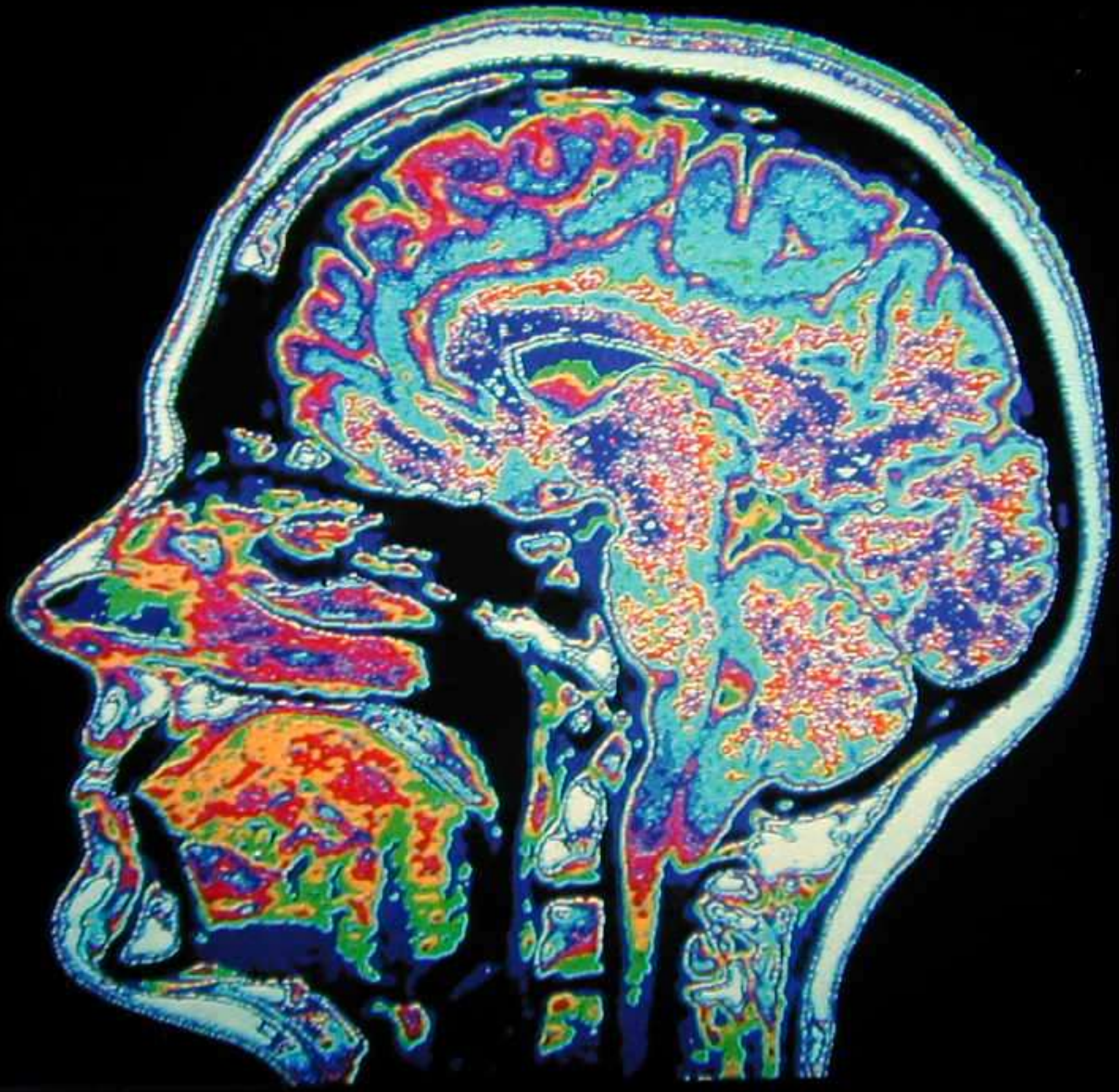
Current Trends in Brain Injury Rehabilitation: Evidence Informed Best Practices “



Alan H. Weintraub, MD
Medical Director
TBI Program, Craig Hospital
Rocky Mountain Regional Brain Injury System

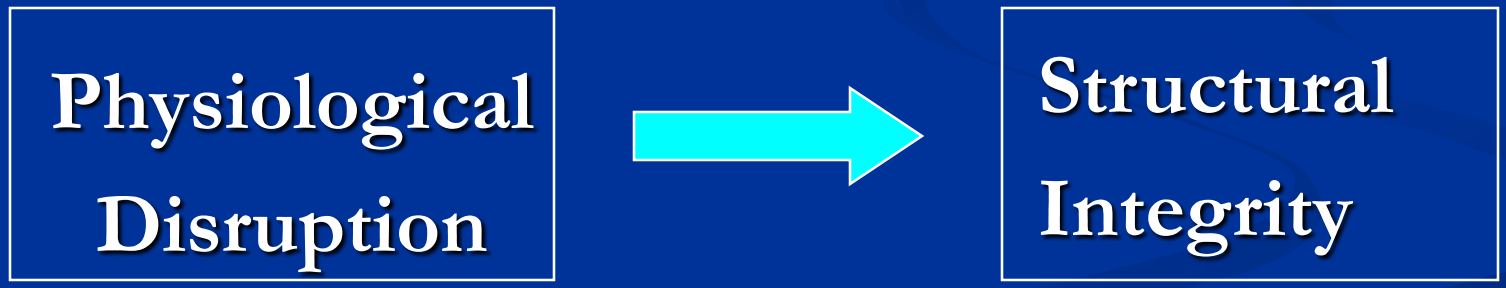
Predictive Determinants of Outcome

- Type and severity of neurological injury
- Type and severity of bodily injuries
- Pre-injury characteristics (biological, social)
- Psychosocial co-morbidities
- Supports, treatment paradigms, environment



Neuropathology of Head Injuries
Gennarelli and Graham: 1998

TBI is a Process not an Event

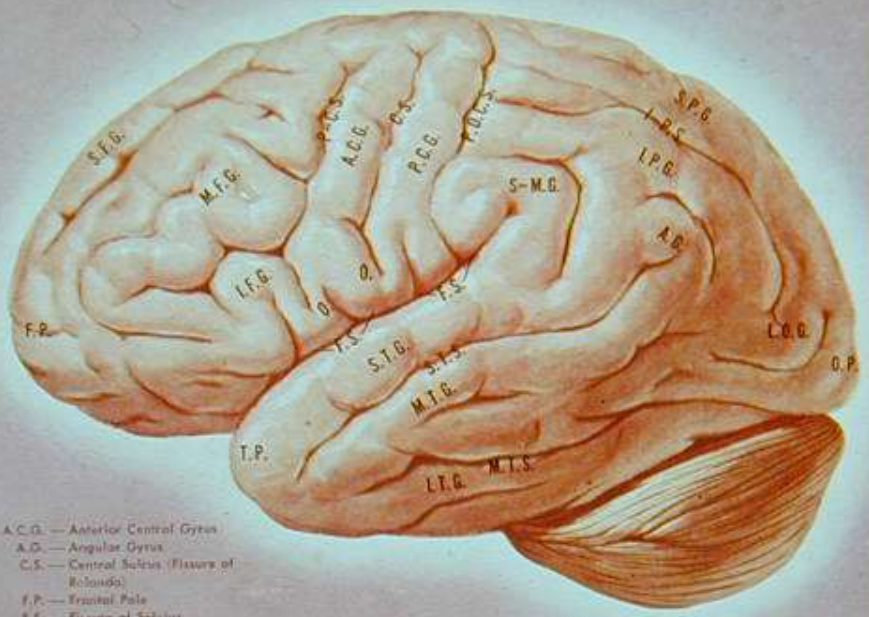


RECOVERY PATTERNS

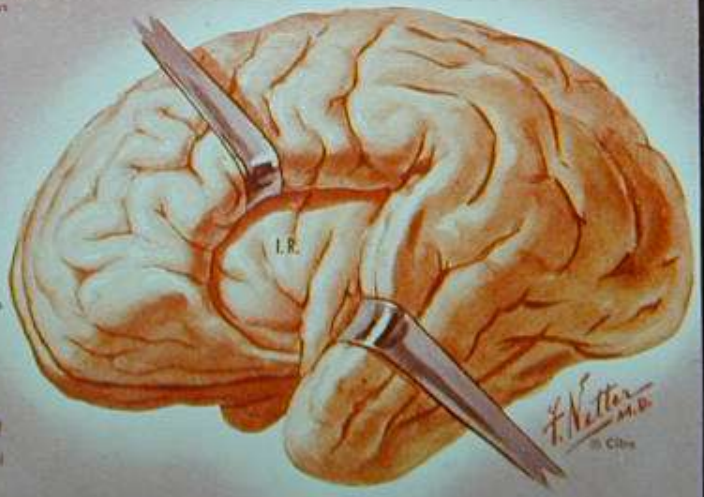
- Not Random
- CHI-more specific
- Neurological and semi-predictable
- Correlates with clinical and diagnostics

Specific Types of Injuries

- Diffuse Injury
- Diffuse Axonal Injury
- Focal
- Multi-Focal/ Mixed
- Hypoxia--Ischemia



A.C.G. — Anterior Central Gyrus
A.G. — Angular Gyrus
C.S. — Central Sulcus (Fissure of Rolando)
F.P. — Frontal Pole
F.S. — Fissure of Sylvius
I.F.G. — Inferior Frontal Gyrus
I.P.G. — Inferior Parietal Gyrus
I.P.S. — Inter-Parietal Sulcus
I.R. — Island of Reil
I.T.G. — Inferior Temporal Gyrus
L.O.G. — Lateral Occipital Gyrus
M.F.G. — Middle Frontal Gyrus
M.T.G. — Middle Temporal Gyrus
M.T.S. — Middle Temporal Sulcus
O. — Operculum
O.P. — Occipital Pole
P.C.G. — Posterior Central Gyrus
P.C.S. — Pre-Central Sulcus
P.O.C.S. — Post-Central Sulcus
S.F.G. — Superior Frontal Gyrus
S.M.G. — Supra-Marginal Gyrus
S.P.G. — Superior Parietal Gyrus
S.T.G. — Superior Temporal Gyrus
S.T.S. — Superior Temporal Sulcus
T.P. — Temporal Pole



LATERAL ASPECT OF BRAIN

INJURY SEVERITY RELATES TO AXONAL FUNCTION

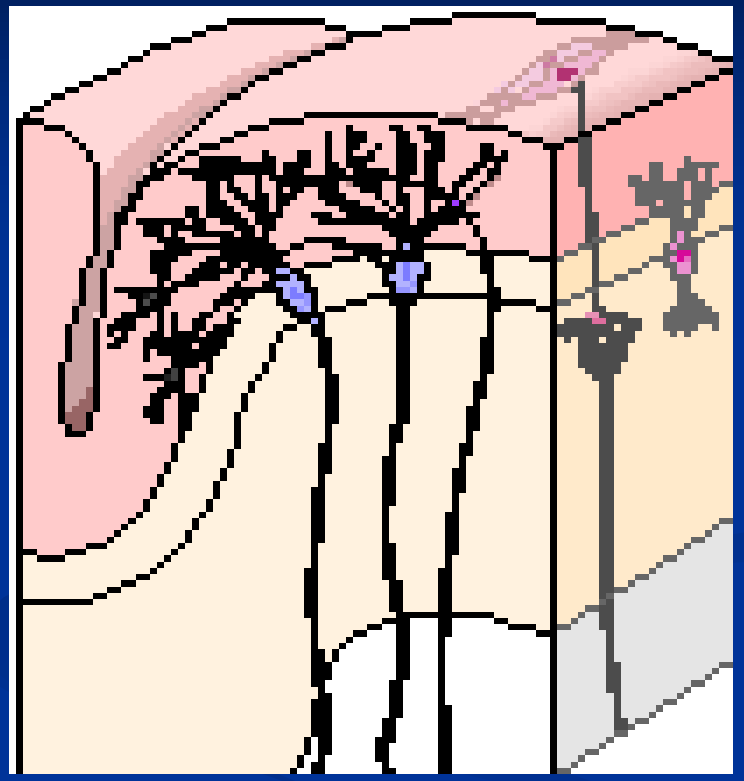
Physiologic → → → Anatomic Disruption

SPECTRUM OF DIFFUSE BRAIN INJURY

- Mild Concussion
- Classical Cerebral Concussion
- Diffuse Injury
- Diffuse White Matter Shearing

Increasing Disruption of Axonal Fibers

Diffuse Axonal Injury (DAI)



Clinical Indicators

Depth of unconsciousness (LOC)

Duration of disturbed consciousness (PTA)

Spectrum of Injury Severity (Surrogate Clinical Tools)

- Glasgow Coma Scale (GCS) depth of unconsciousness
- Time to Follow Commands (TFC) duration of unconsciousness
- Post-traumatic amnesia (GOAT)
- Neuroimaging and other diagnostics
- Clinical exam

GLASGOW COMA SCALE

Eye Opening

4 = Spontaneously

3 = To Voice

2 = To Pain

1 = None

Verbal Response

5 = Oriented

4 = Confused

3 = Inappropriate Words

2 = Incomprehensible Sounds

1 = None

Motor Response

6 = Follows Commands

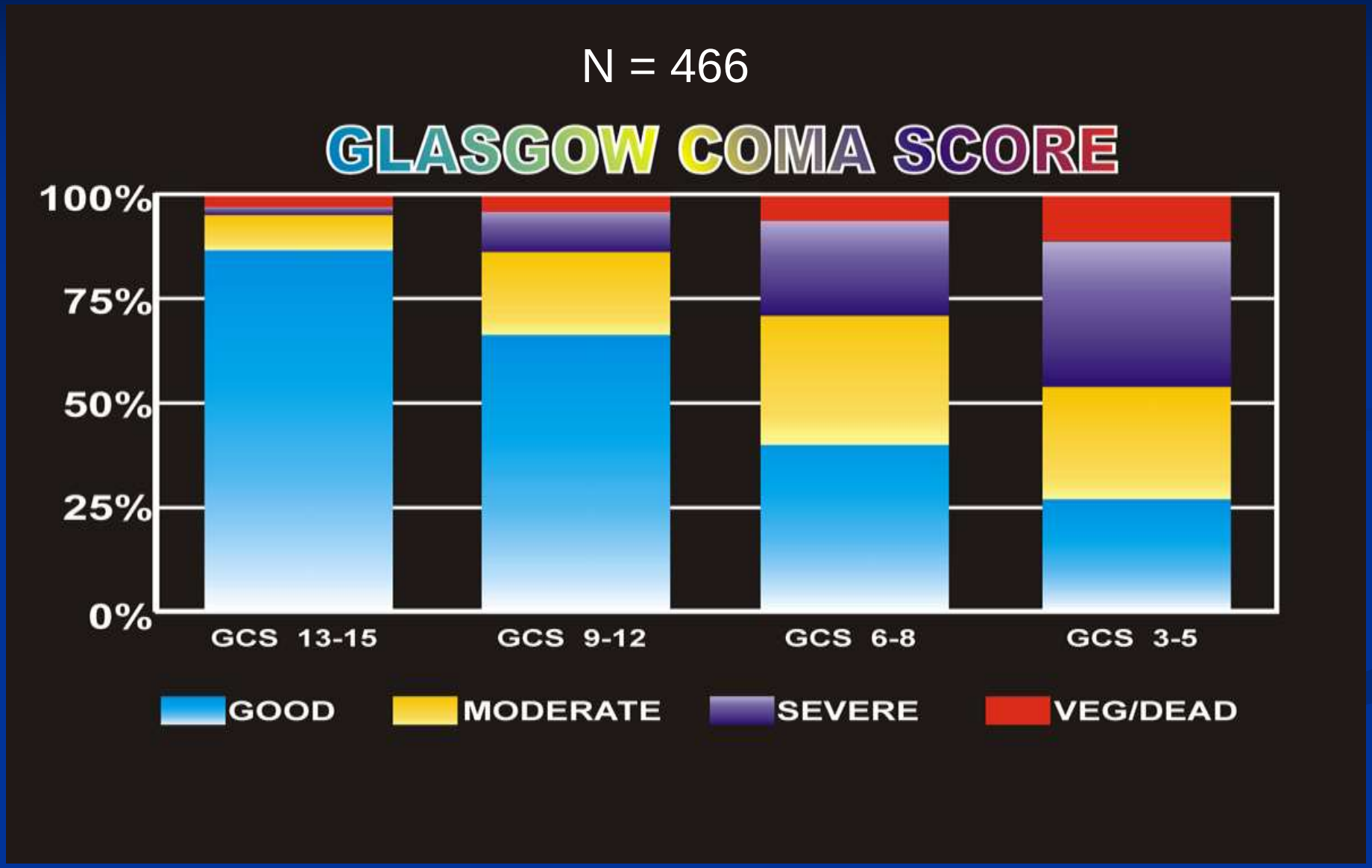
5 = Localizes to Pain

4= Withdrawal to Pain

3 = Abnormal Flexion

2 = Abnormal Extension

One year psychosocial outcome in head injury
Dikmen, 1999



Cumulative Percent of Head-Injured Subjects Who Return to Work

% Returned to Work

Characteristics	
Demographics	12 months
Neurological Severity	
GCS	
<8	26
9-12	56
13-15	80

Head-injury severity was assessed by the Glasgow Coma Scale (GCS) obtained in the emergency department and by time to follow commands.

The GCS evaluates depth of coma by responsiveness in eye opening, motor and verbal modalities.

-Dikmen 1999

Cumulative Percent of Head-Injured Subjects Who Return to Work

% Returned to Work

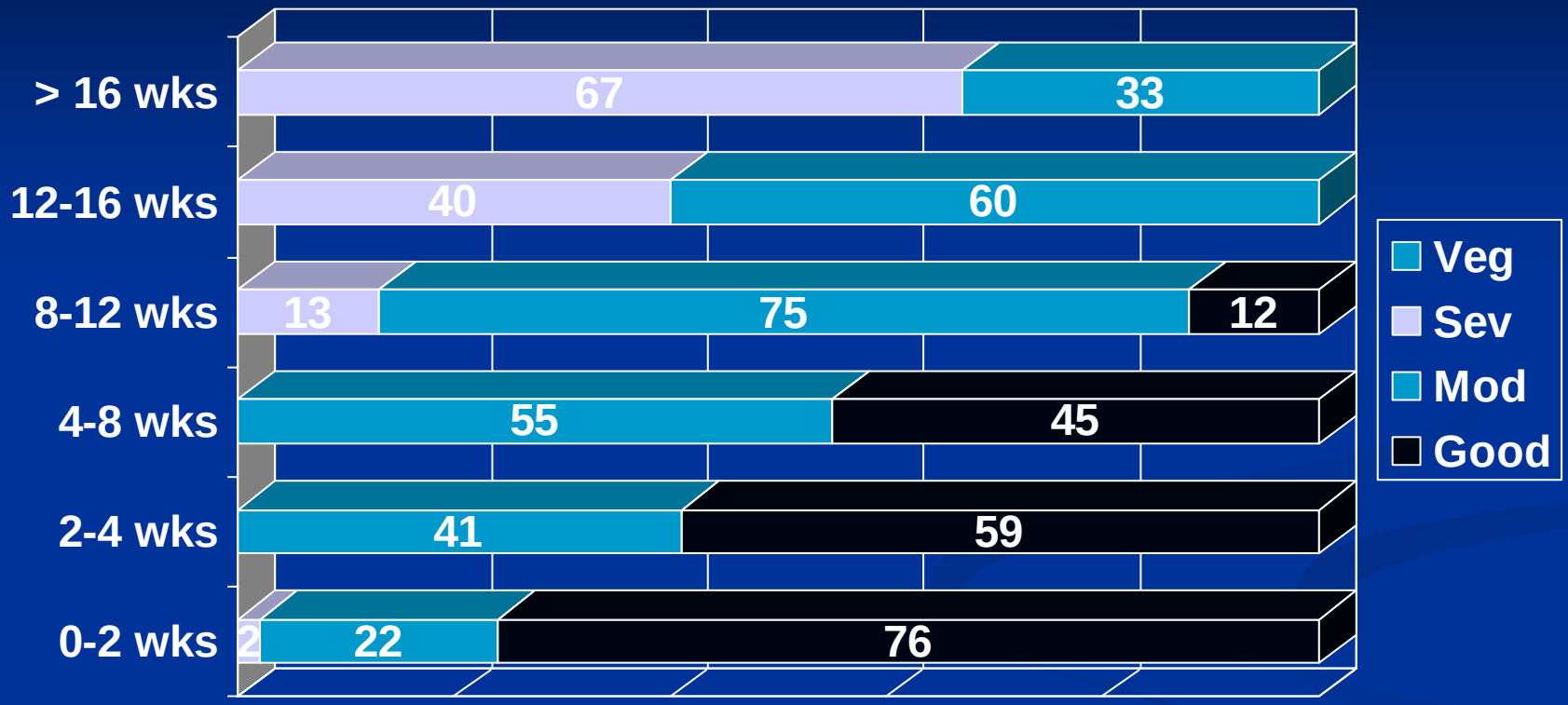
Characteristics	
Demographics	12 months
Time to Follow Commands	
Neurological Severity	
TFC	
<5 h	82
6-24 h	67
25 H-6 d	67
7-13 d	46
14-28 d	21
>29 d	6

Time to follow commands was used as a measure to length of coma and was operationally defined as the duration of time between the injury and the patients' regaining the ability to respond consistently to verbal commands as defined by the motor component of the GCS.

-Dikmen 1999

Acute Signs of Traumatic Brain Injury

PTA Duration and One Year Outcome



Outcome probability at one year post injury in a group of patients admitted to inpatient rehabilitation with moderate to severe traumatic brain injury classified by duration of posttraumatic amnesia (PTA). Outcomes are categorized by the by Glasgow Outcome Scale (veg., vegetative state; sev. Severe disability's mod. Moderate disability; good, good recovery).

-Levin etal, dikmen etal, Katz alexander

SPECTRUM OF DIFFUSE BRAIN INJURY

- Mild Concussion
- Classical Cerebral Concussion
- Diffuse Injury
- Diffuse White Matter Shearing

Increasing Disruption of Axonal Fibers

MILD TBI

Predictors of Outcome – Risk Factors

- Medical
- Psychological Processes
- Environmental

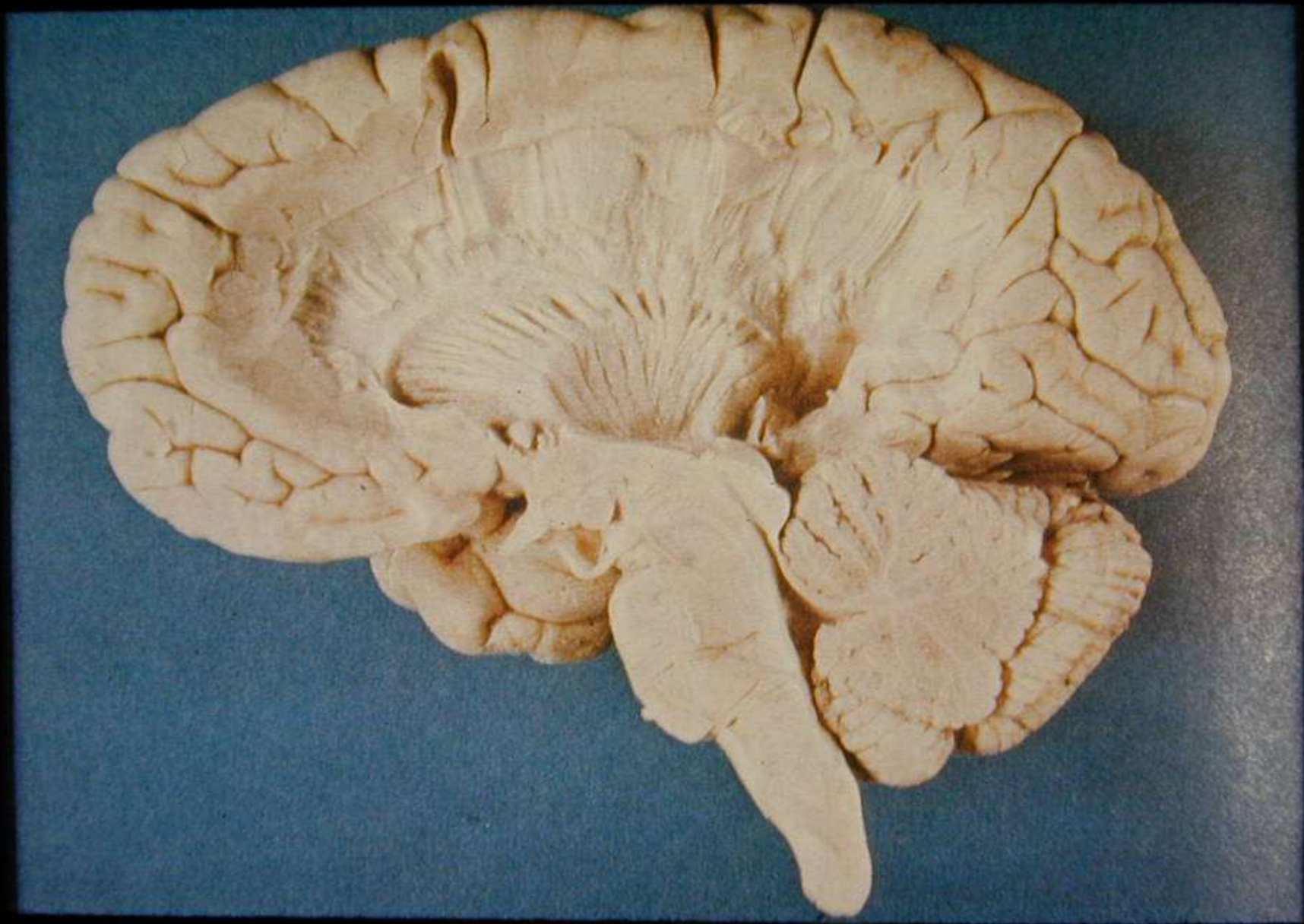
DIFFUSE INJURY

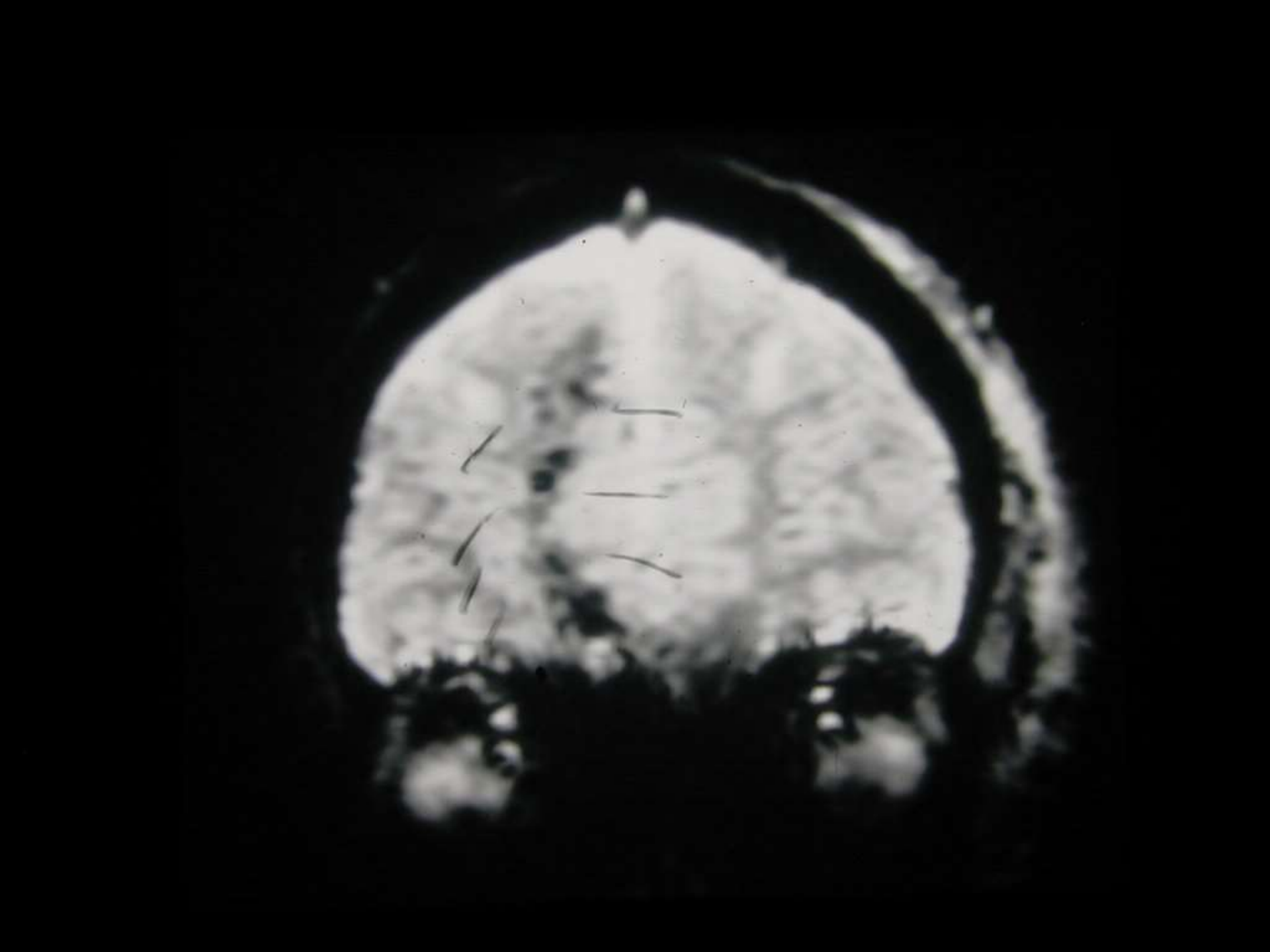
LOC > 24 Hours

Generalized Damage to Axonal Structure

or

Brain White Matter





EIGHT STAGES OF COGNITIVE RECOVERY FOR HEAD TRAUMA

- Level I - Coma
- Level II - Generalized Response
- Level III - Localized Response
- Level IV - Confused/Agitated
- Level V - Confused/Inappropriate/Non-agitated
- Level VI - Confused/Appropriate
- Level VII - Automatic/Appropriate
- Level VIII - Purposeful/Appropriate

Case 1

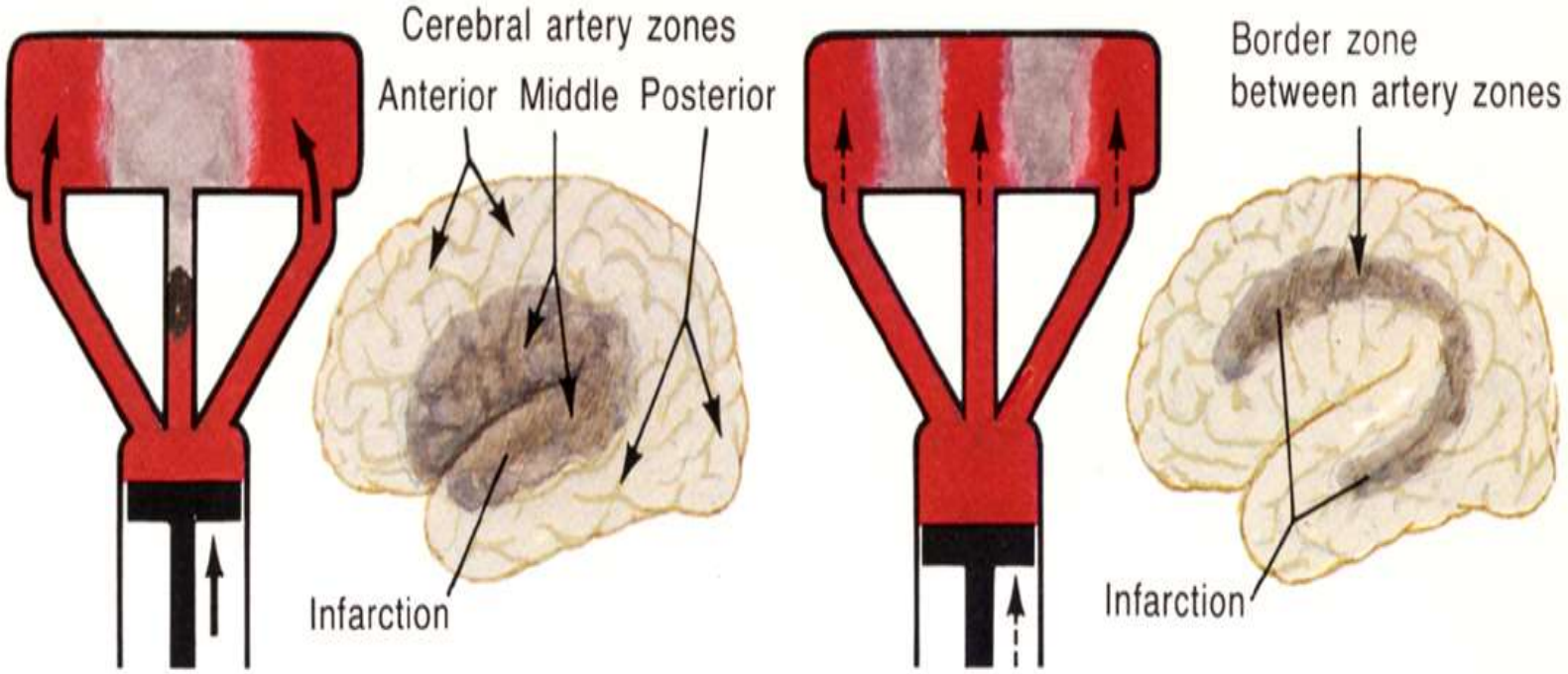
DAI
GCS 4
TFC 4 weeks
PTA 3 months ?

Severe DAI Syndromes (Differential)

- Vegetative State (disconnection bs, wm, th, ctx)
- Minimal Responsive State (white matter)
- Akinetic Mutism (supplemental motor area)
- Locked-Out Syndrome (thalamic)
- Locked-In and Locked In Plus (brainstem)

Hypoxia - Ischemia

Border zone ischemia (shock, circulatory insufficiency)



Hypoxic and/or Ischemic Patterns

- Hippocampal cells (amnestic)
- Purkinge cerebellar cells (dystaxic)
- Basal Ganglia (parkinsonian spectrum)
- Watershed or "Borderzones" (dyspraxia, visual perceptual, motor planning, tactile auditory and visual defensiveness)
- Mixed Pattern (movement disorders,myoclonus)

THE NEUROBIOLOGY OF INJURY

- Neurodiagnostic advances
- Development of novel and innovative therapies

NEUROIMAGING ADVANCES
Expanded Understanding of Injury Relationships

- Anatomy - CT
  - MRI
  - MRA

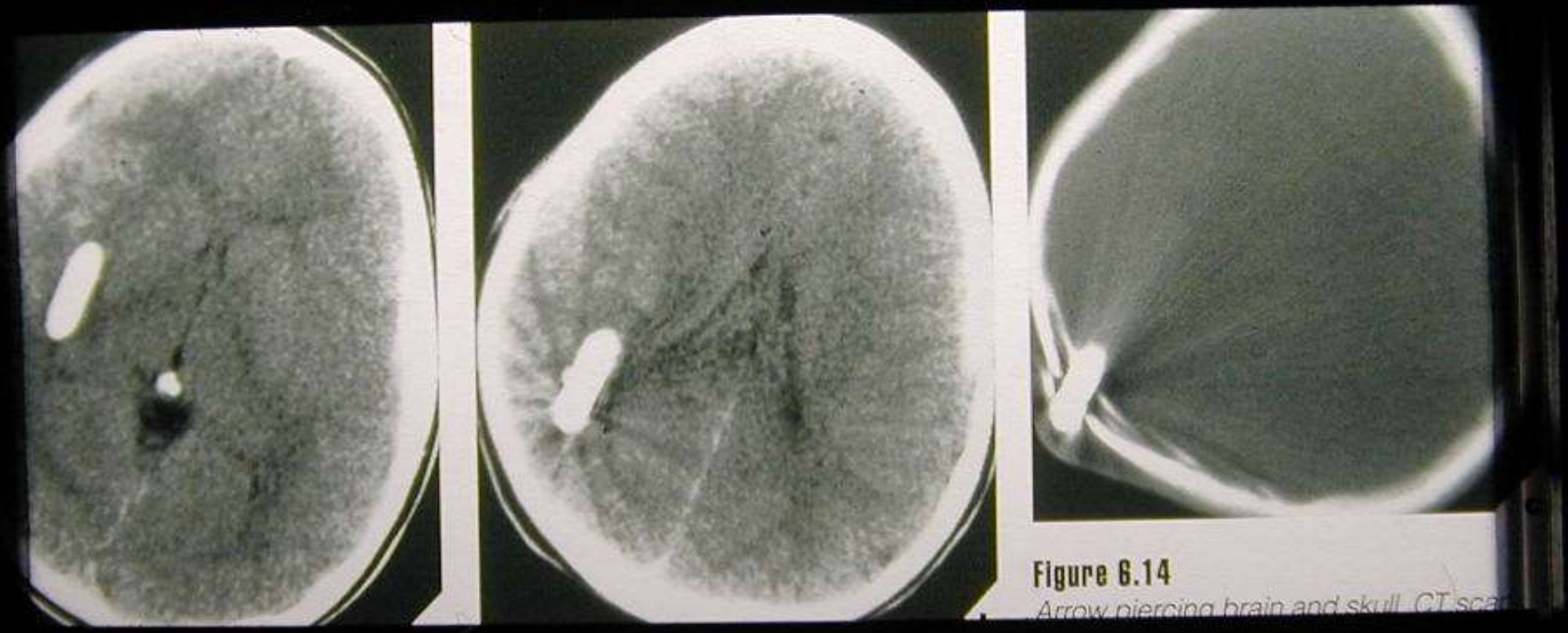
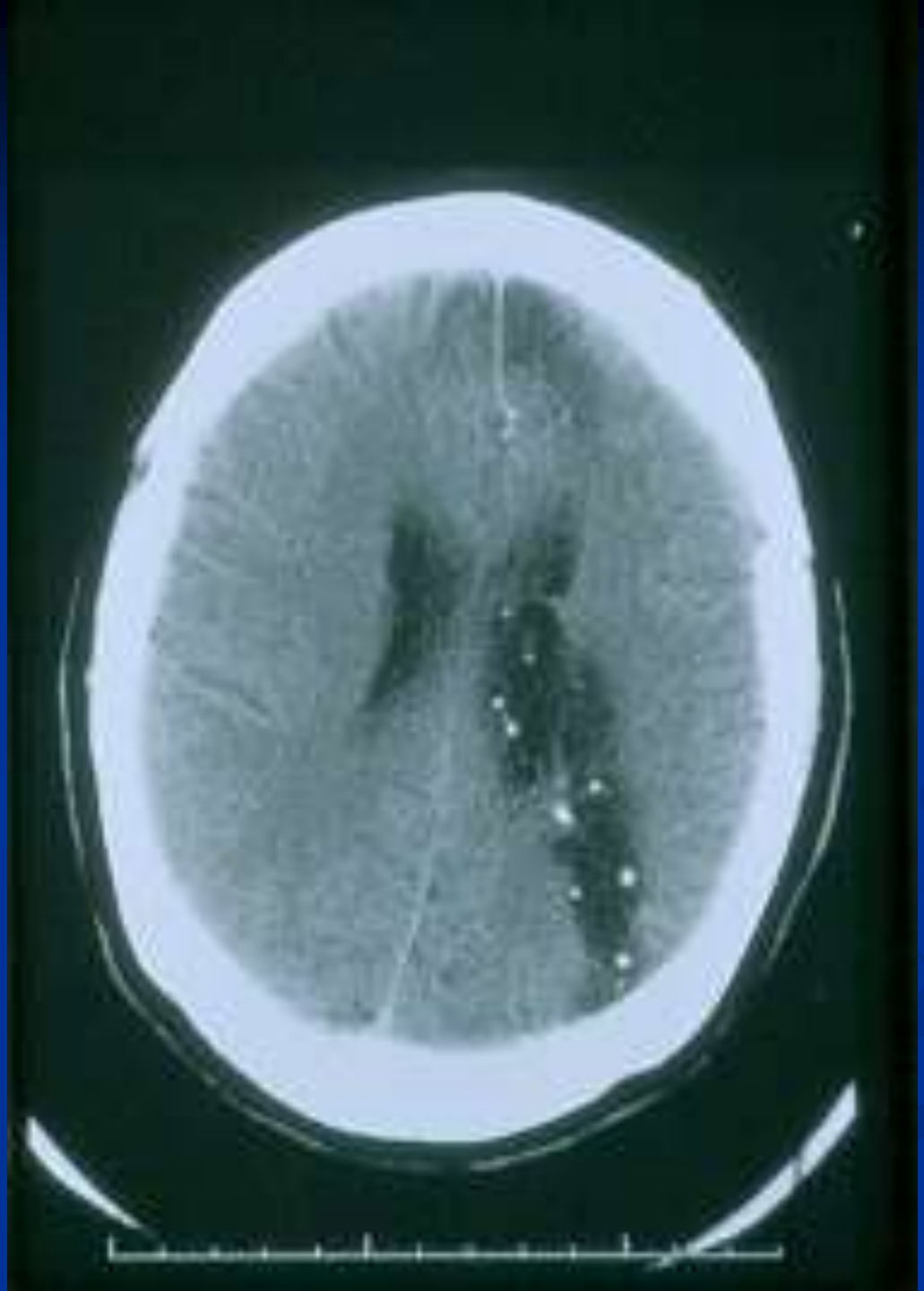


Figure 6.14

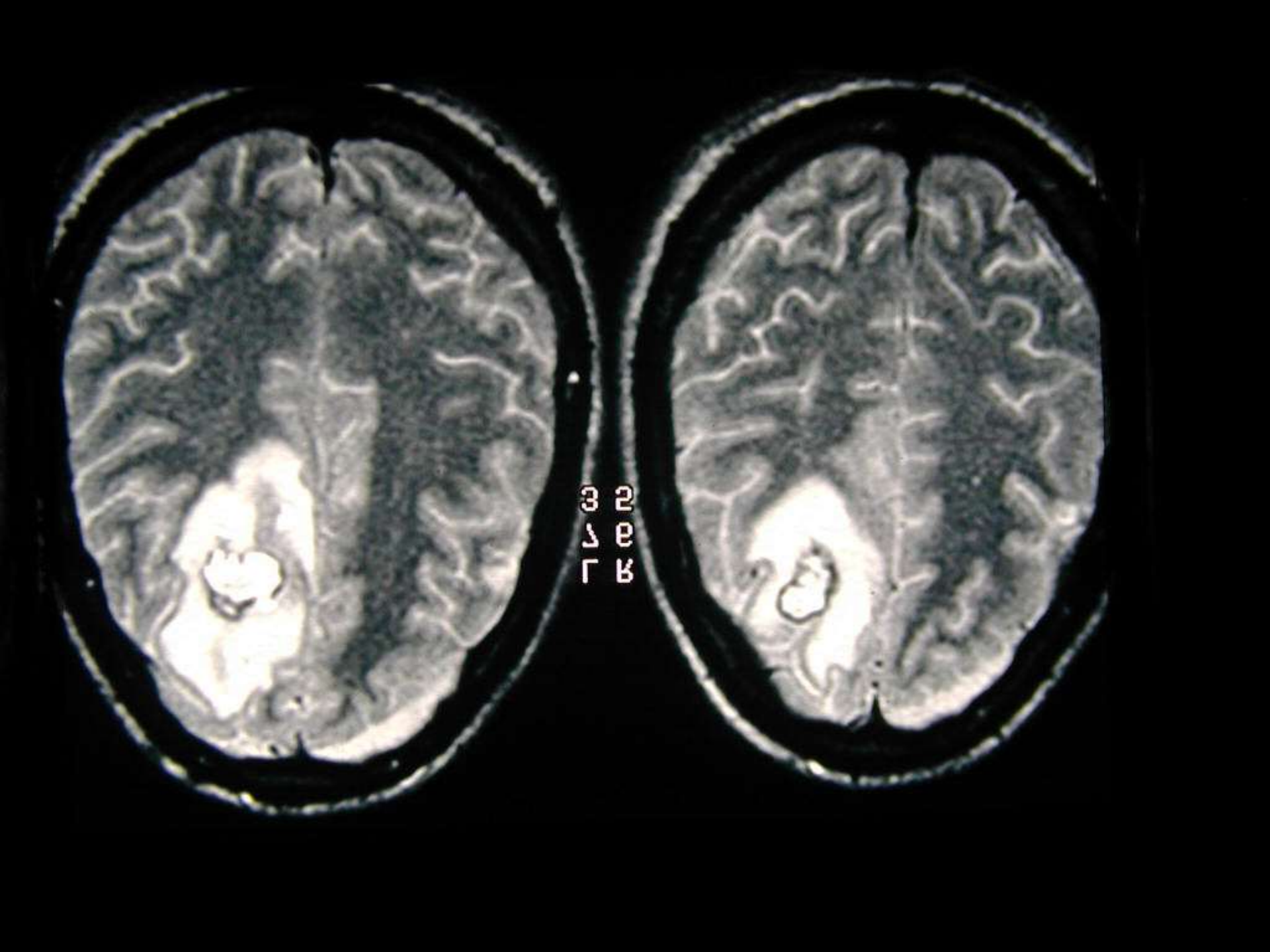
Arrow piercing brain and skull. CT scan



LACERATIONS

HEMATOMAS

- Extradural
- Subdural
- Intracerebral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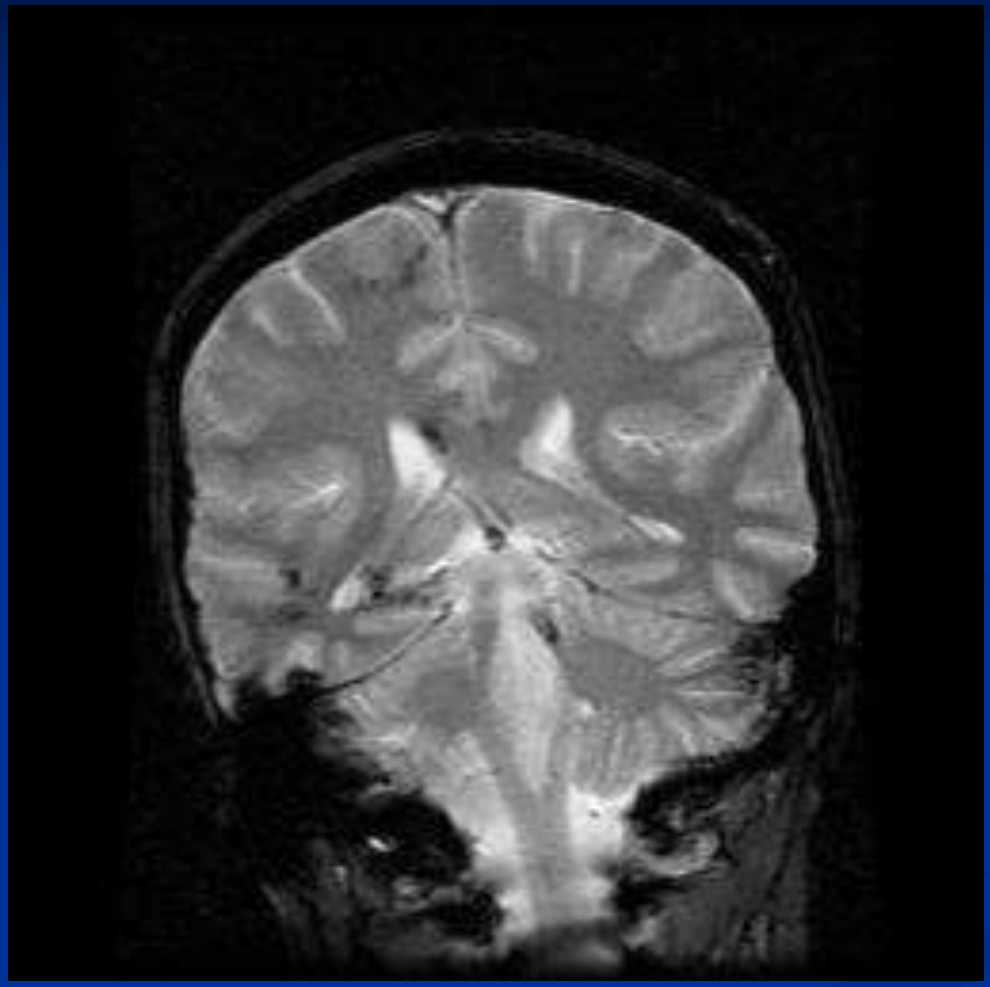


NEUROIMAGING ADVANCES
Expanded Understanding of Injury Relationships

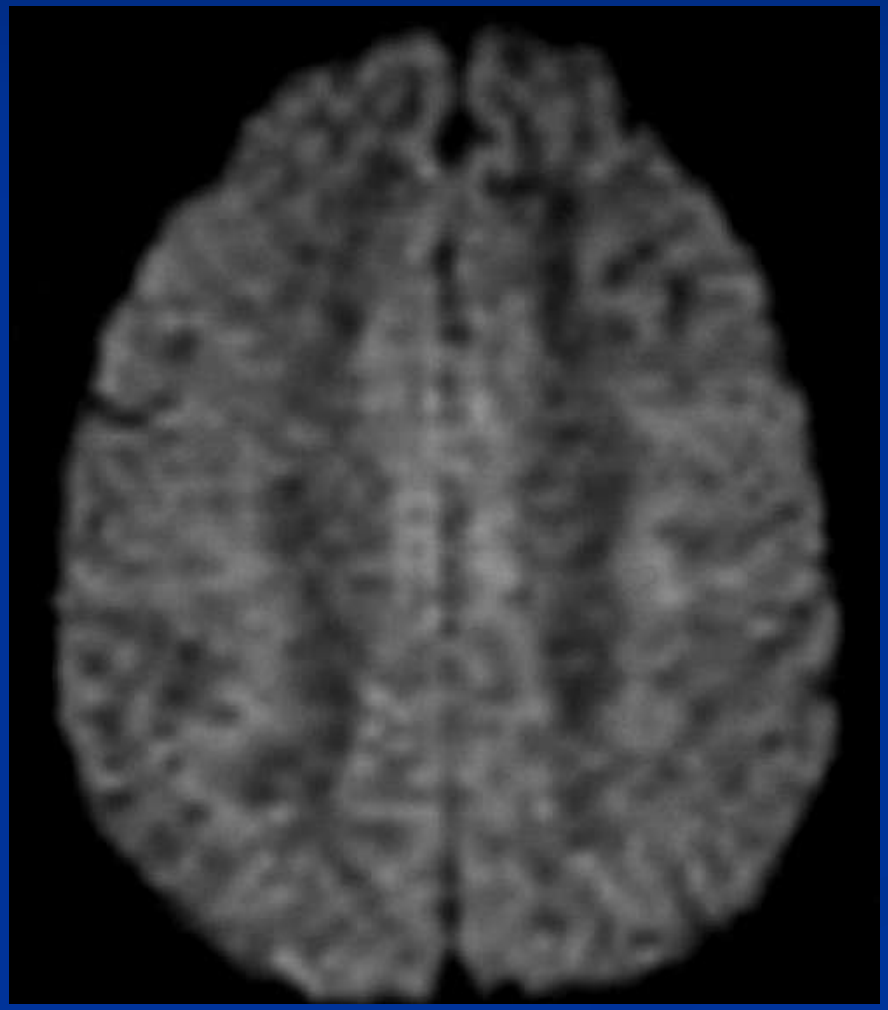
- Anatomy - CT
  - MRI
  - MRA
- **Physiology – Advanced MRI techniques**
  - **SPECT**
  - **PET**
  - **EEG**
  - **Brain Mapping techniques**

MRI in 2001+: Evaluating brain physiology

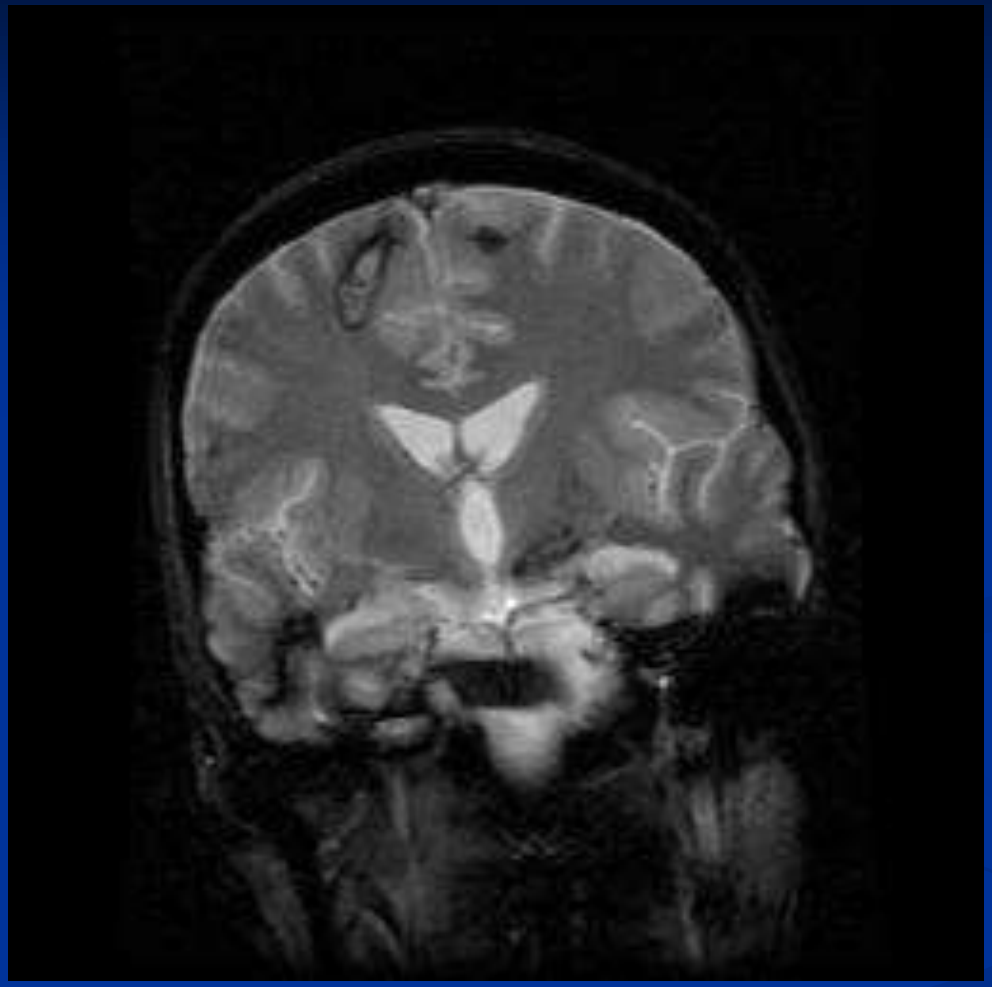
- Goal: Improve diagnostic sensitivity / specificity.
- Tests:
  - Diffusion imaging: evaluates water motion.
  - Perfusion imaging: estimates cerebral blood volume.
  - Spectroscopy: studies tissue metabolism.
  - Functional MR: evaluates brain function.

MR diffusion imaging

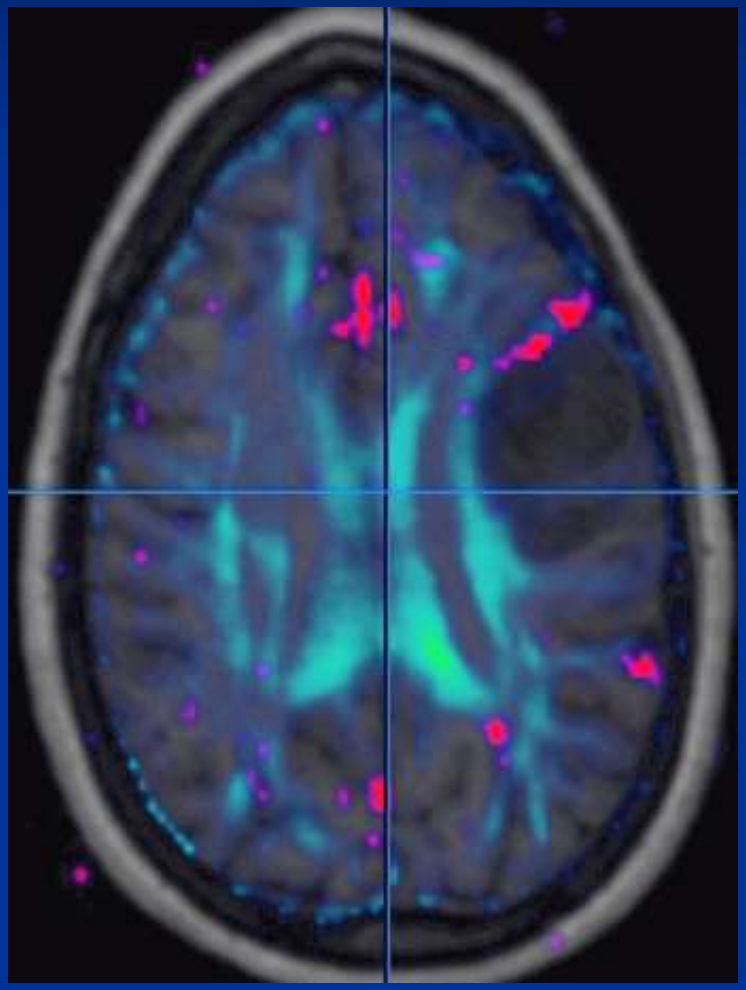
Normal



Abnormal



Tensor & fMRI - Fusion



Combined fMRI Expressive Speech Map with MR Tractography from Diffusion Tensor Imaging

fMRI

- Gradient-echo epiRT
- 26 cm FOV, 128x128
- TE/TR=50/4000ms, 90°
- 65 phases

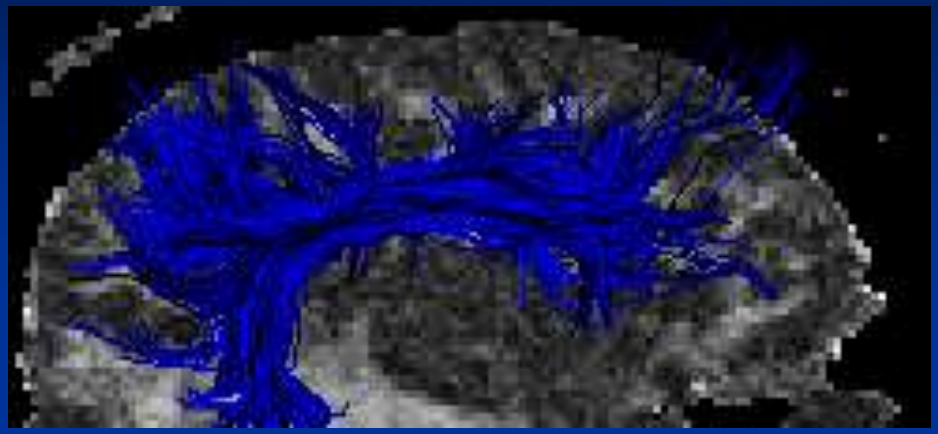
Diffusion Tensor Imaging

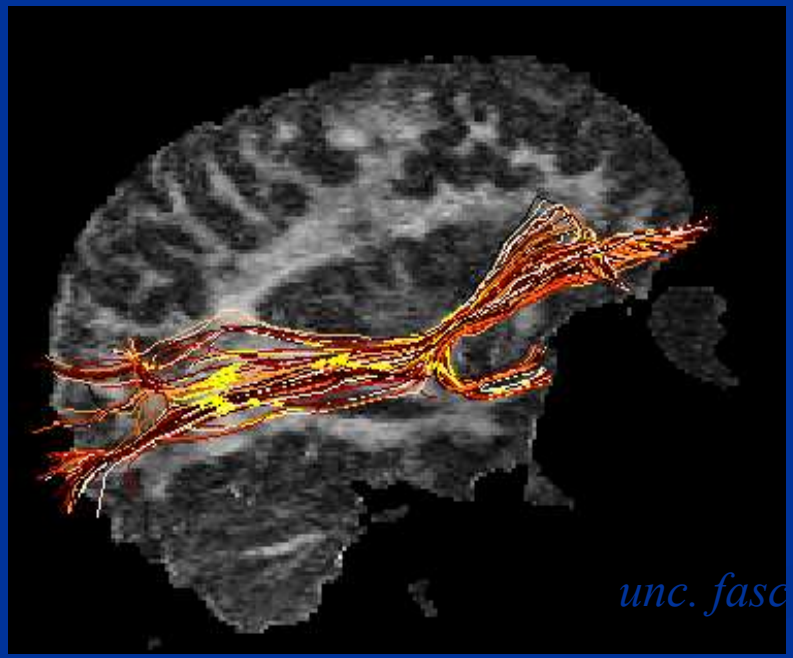
- Six direction encoding, b = 1576 s/mm^2
- SE-EPI, 24 cm FOV, 128x128

Image Courtesy of M.D. Anderson Cancer Center

TRACTOGRAPHY

arc. fasciculus





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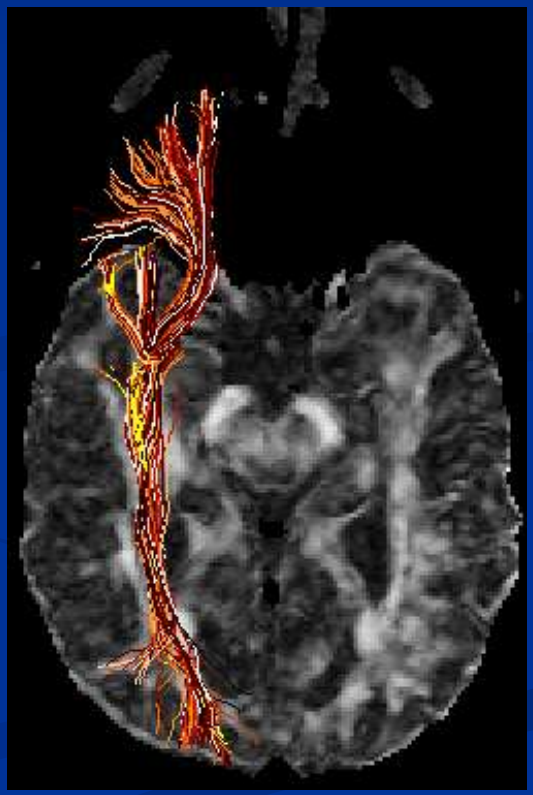
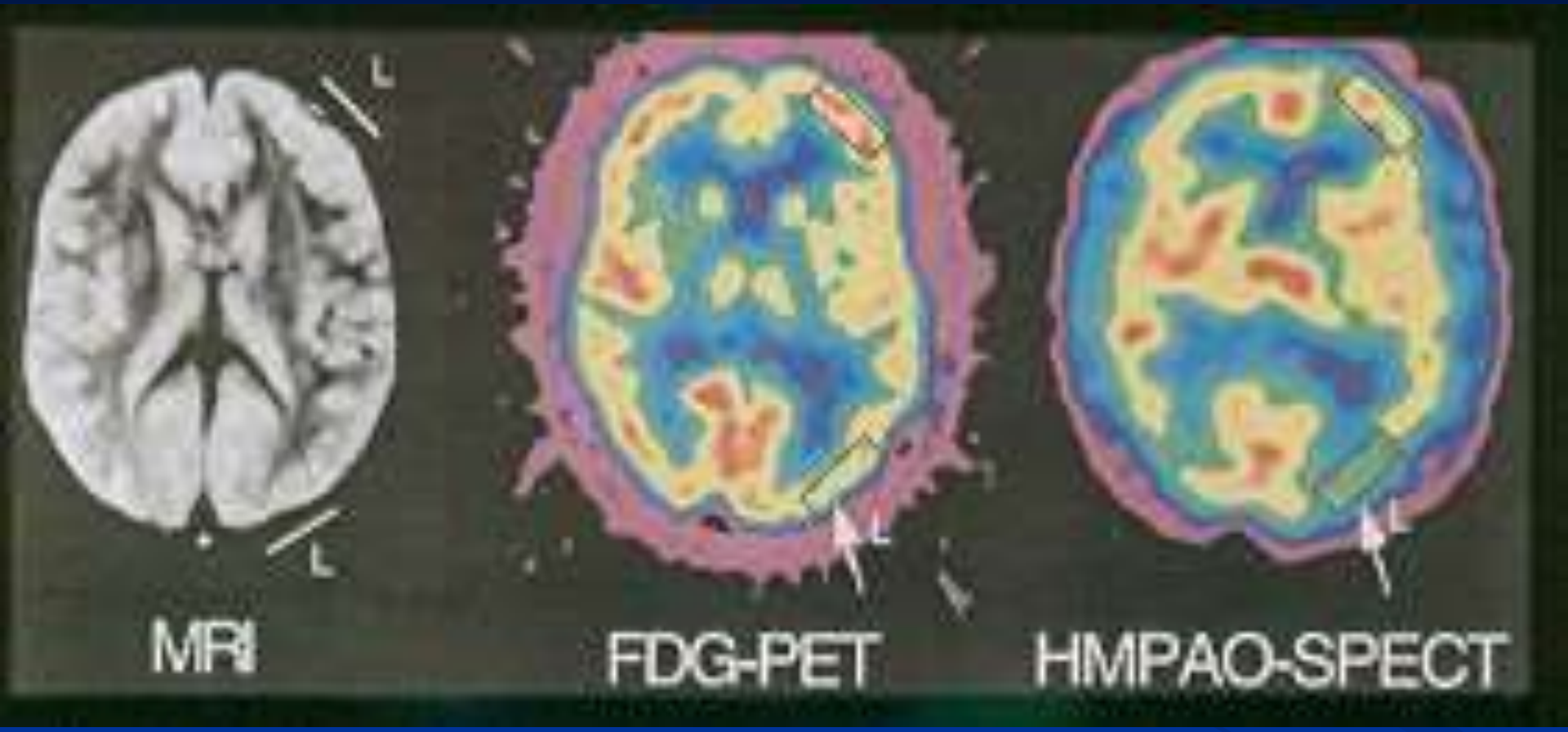
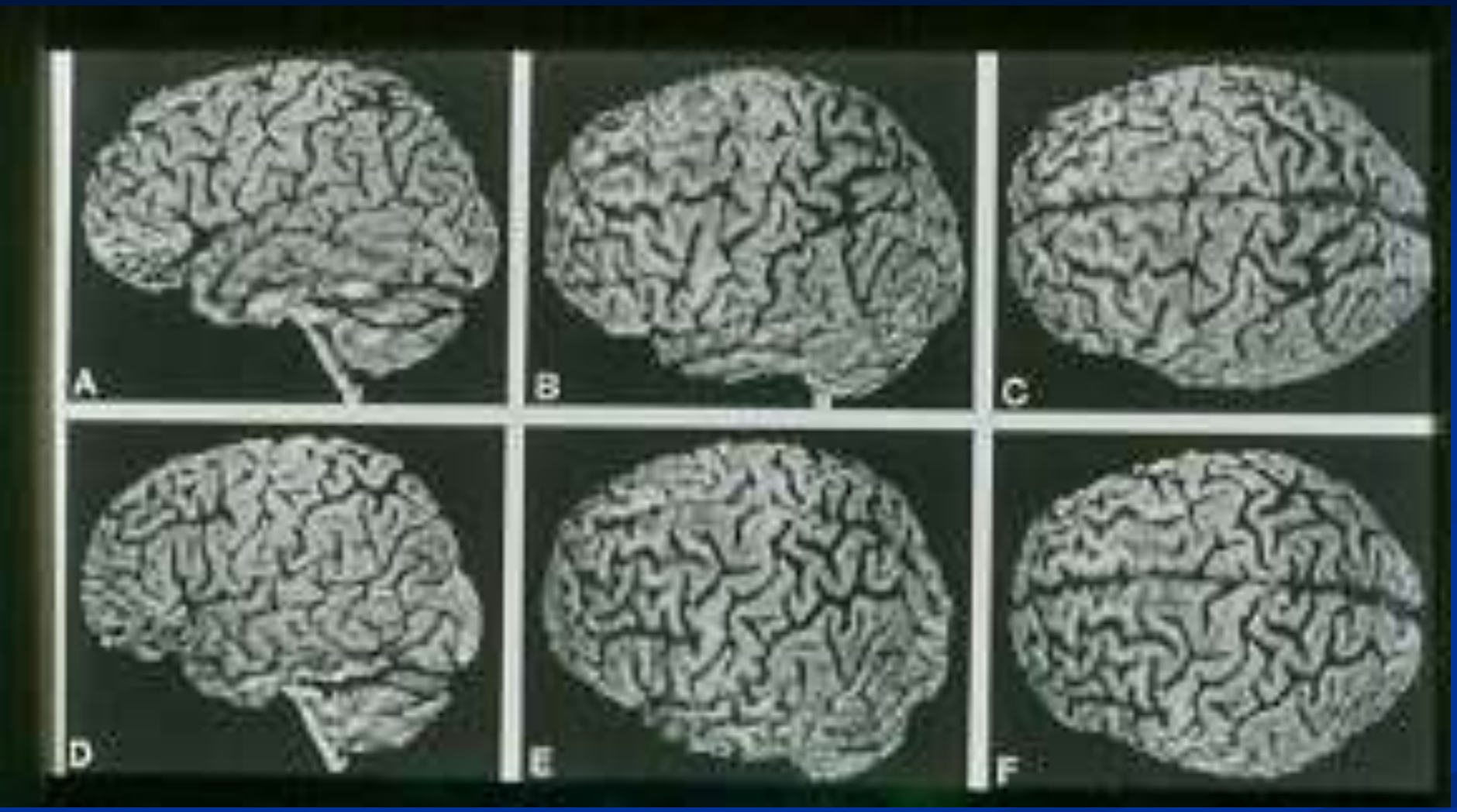



MRI
FDG-PET
HMPAO-SPECT

NEUROIMAGING ADVANCES
Expanded Understanding of Injury Relationships

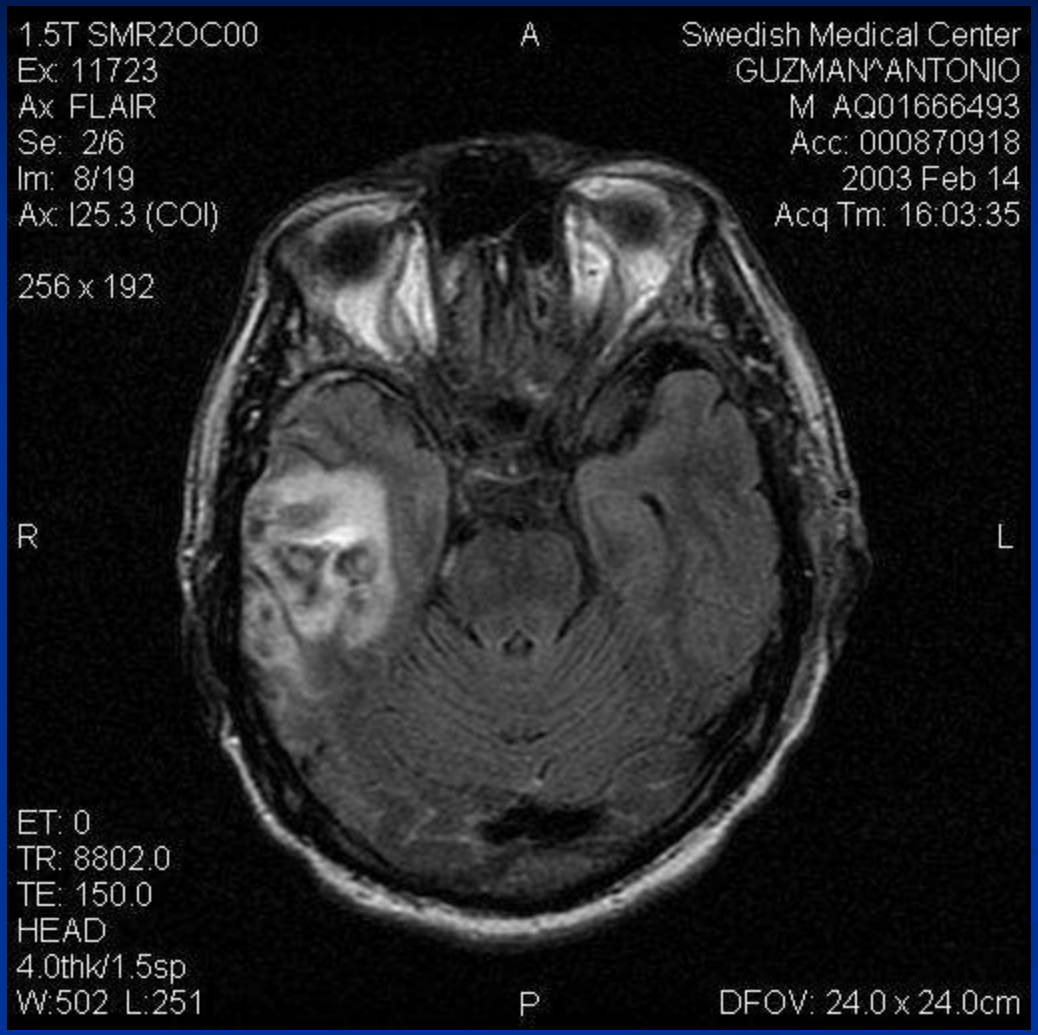
- Anatomy
  - CT
  - MRI
  - MRA
- Physiology – Advanced MRI techniques
  - SPECT
  - PET
  - EEG
  - Brain Mapping techniques
- **Functional**
  - **QMRI**
  - **FMRI**


A
B
C
D
E
F

PREDICTOR RESEARCH

- Advanced Neuro-imaging
- Gender
- Biologic markers – $APOE_4$

DIFFUSE
VS.
FOCAL INJURIES
(emerging or isolated)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Acc: 000870918
2003 Feb 14
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TR: 8802.0
TE: 150.0
HEAD
4.0thk/1.5sp
W:502 L:251
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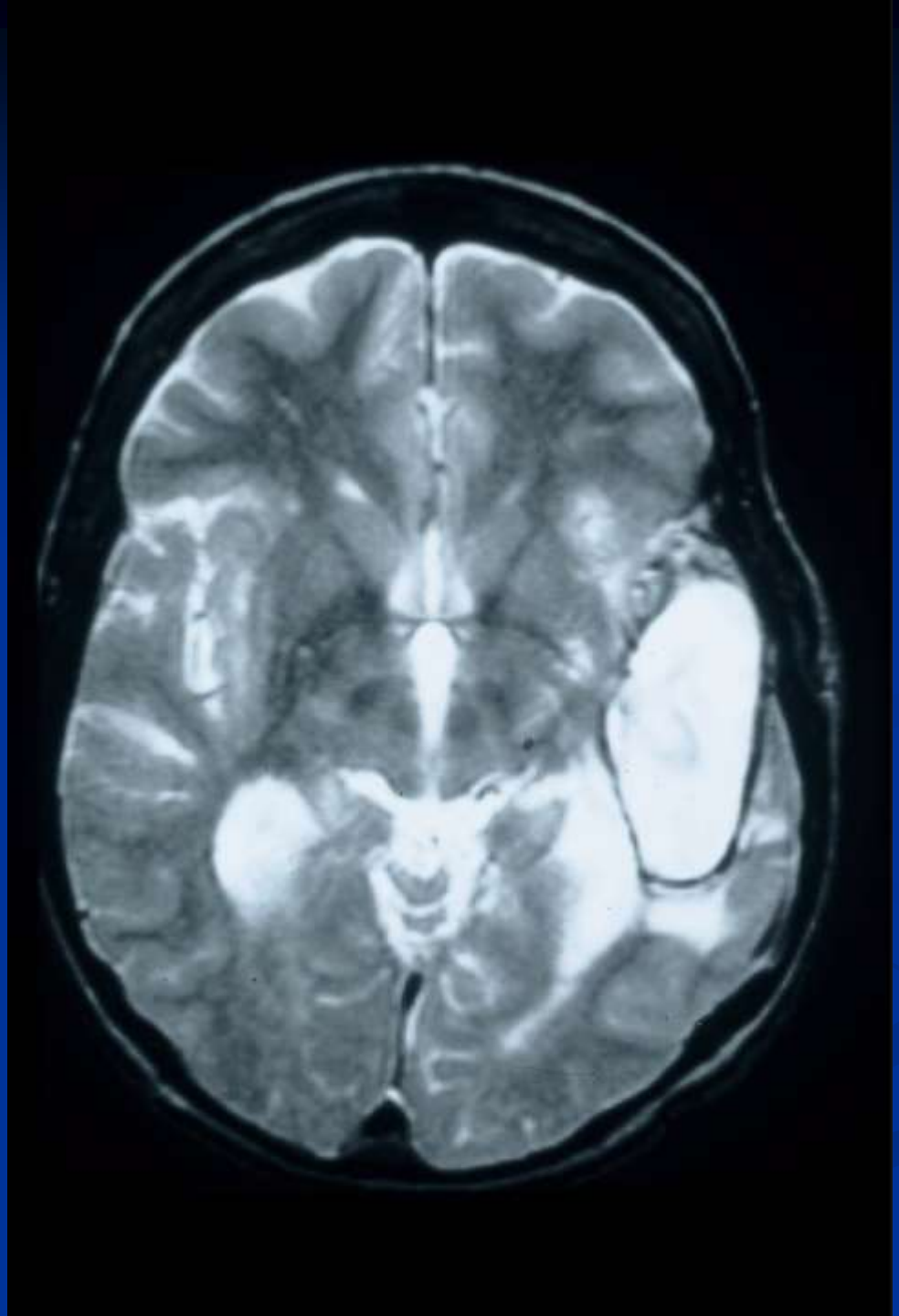
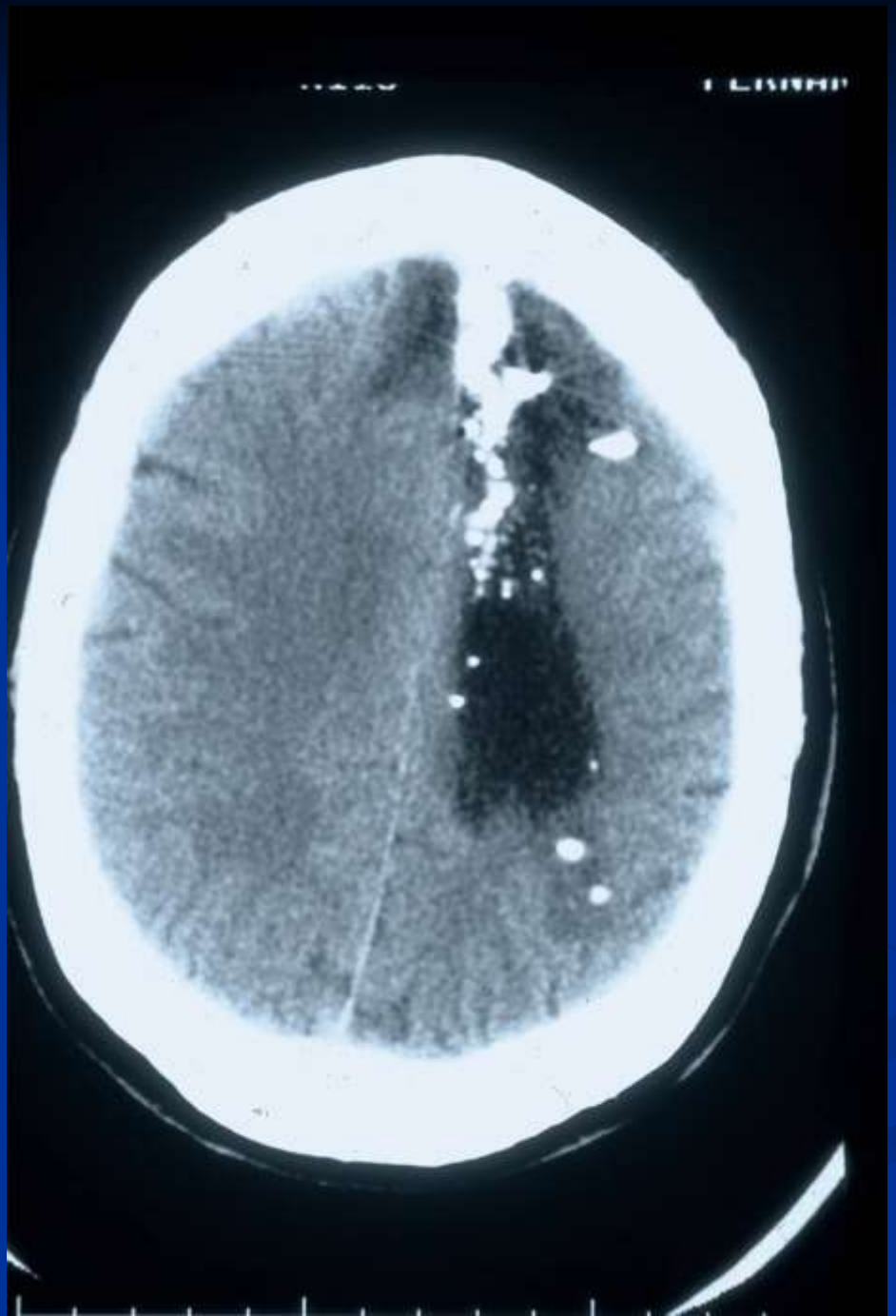
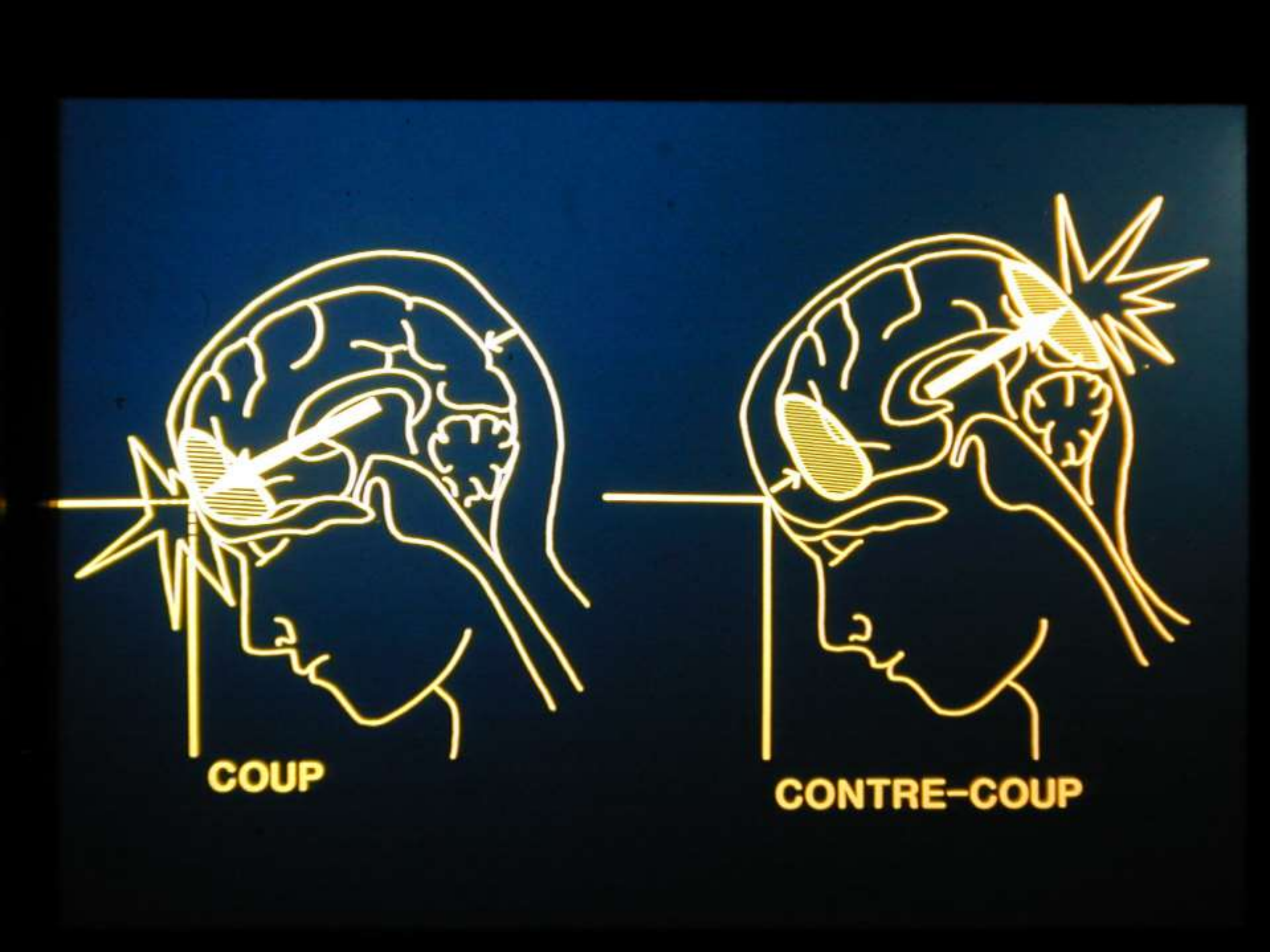
DFOV: 24.0 x 24.0cm

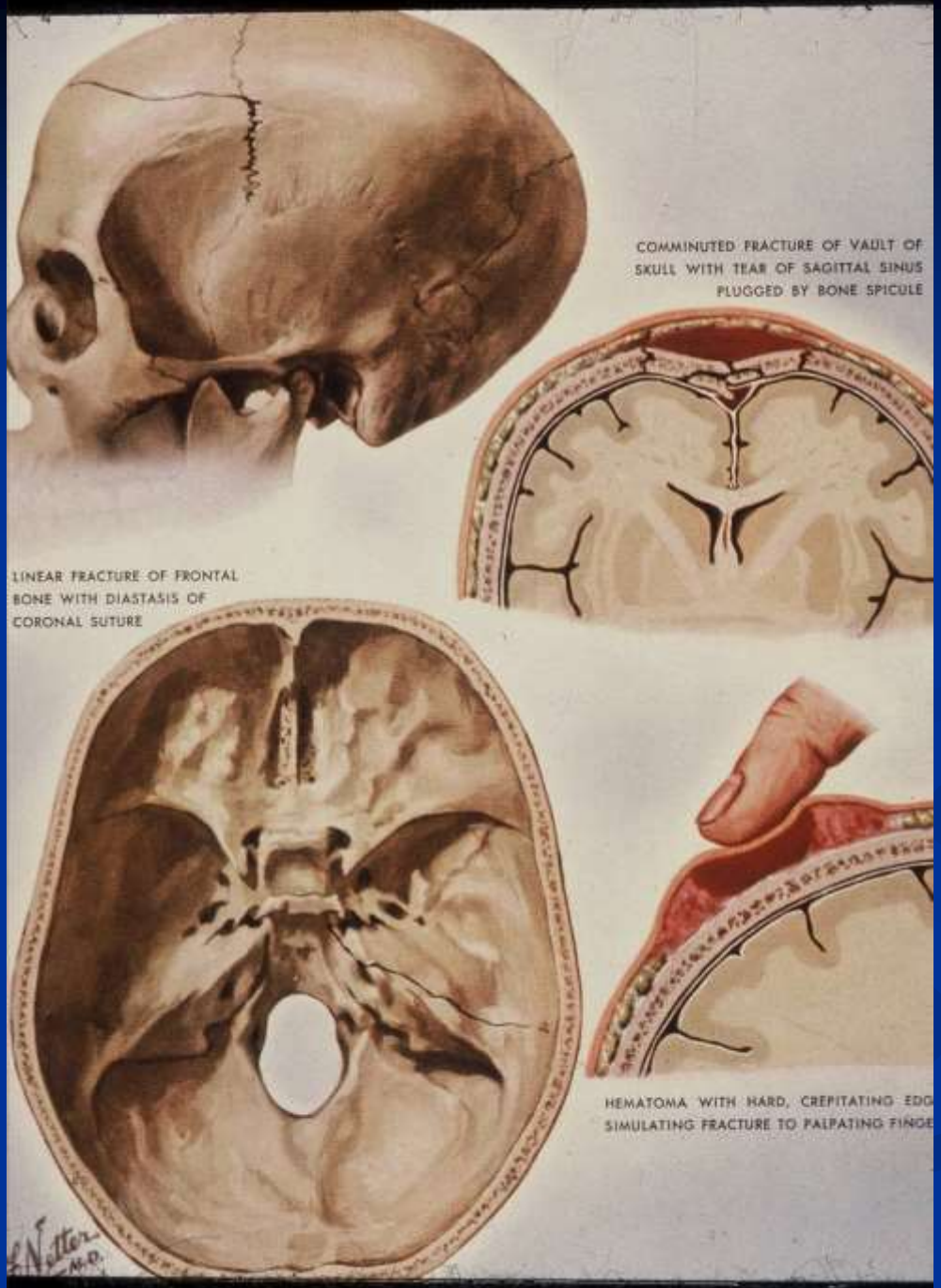


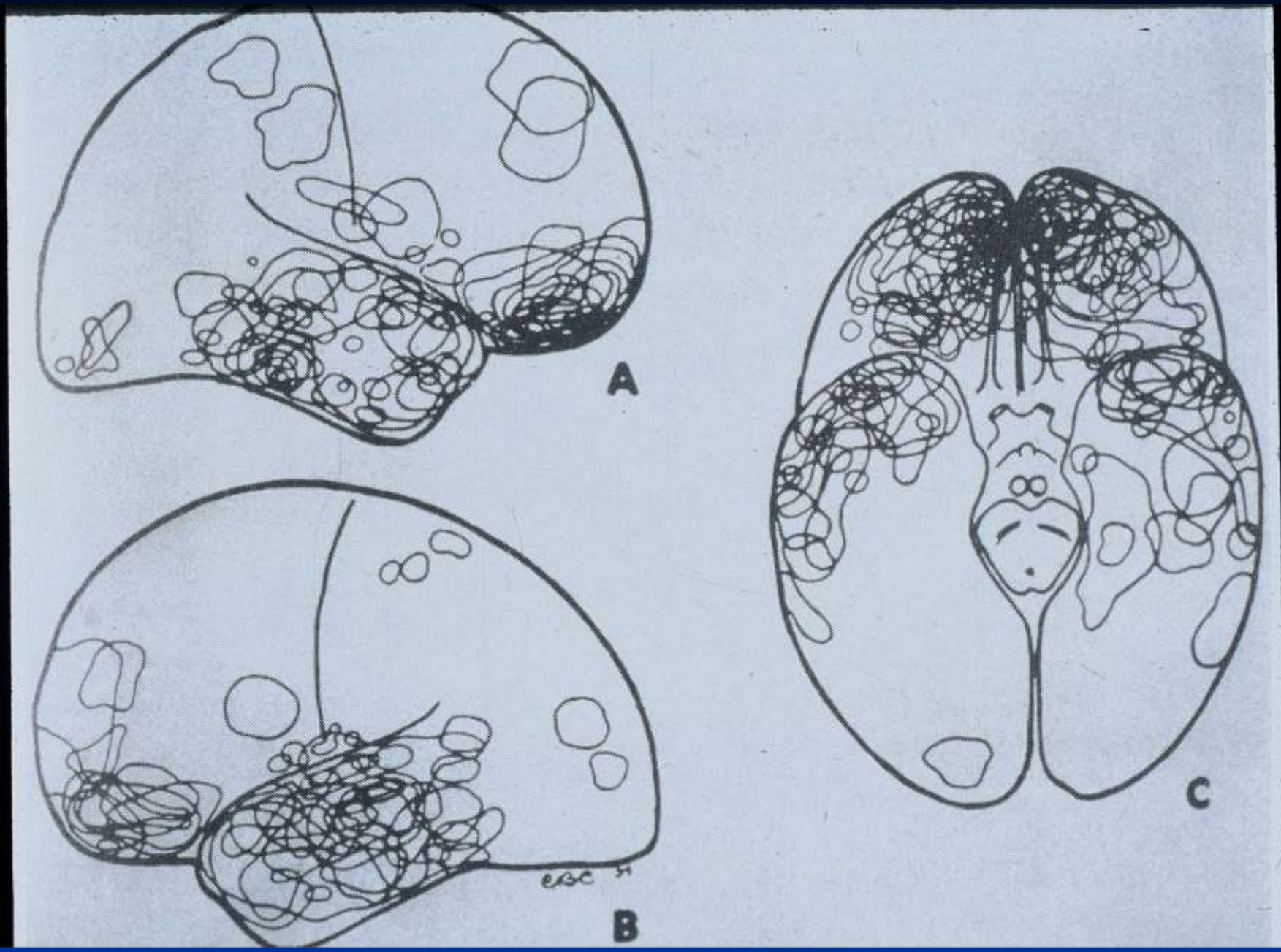
Focal

- Neuroanatomically specific
- Cortical Contusions
- Frequently Frontal and/or Temporal
- GCS,TFC (brief) and disproportionate to PTA
- Physical, Cognitive and Neurobehavioral characteristics




COUP
CONTRE-COUP


COMMINUTED FRACTURE OF VAULT OF SKULL WITH TEAR OF SAGITTAL SINUS PLUGGED BY BONE SPICULE
LINEAR FRACTURE OF FRONTAL BONE WITH DIASTASIS OF CORONAL SUTURE
HEMATOMA WITH HARD, CREPITATING EDG SIMULATING FRACTURE TO PALPATING FINGE


A
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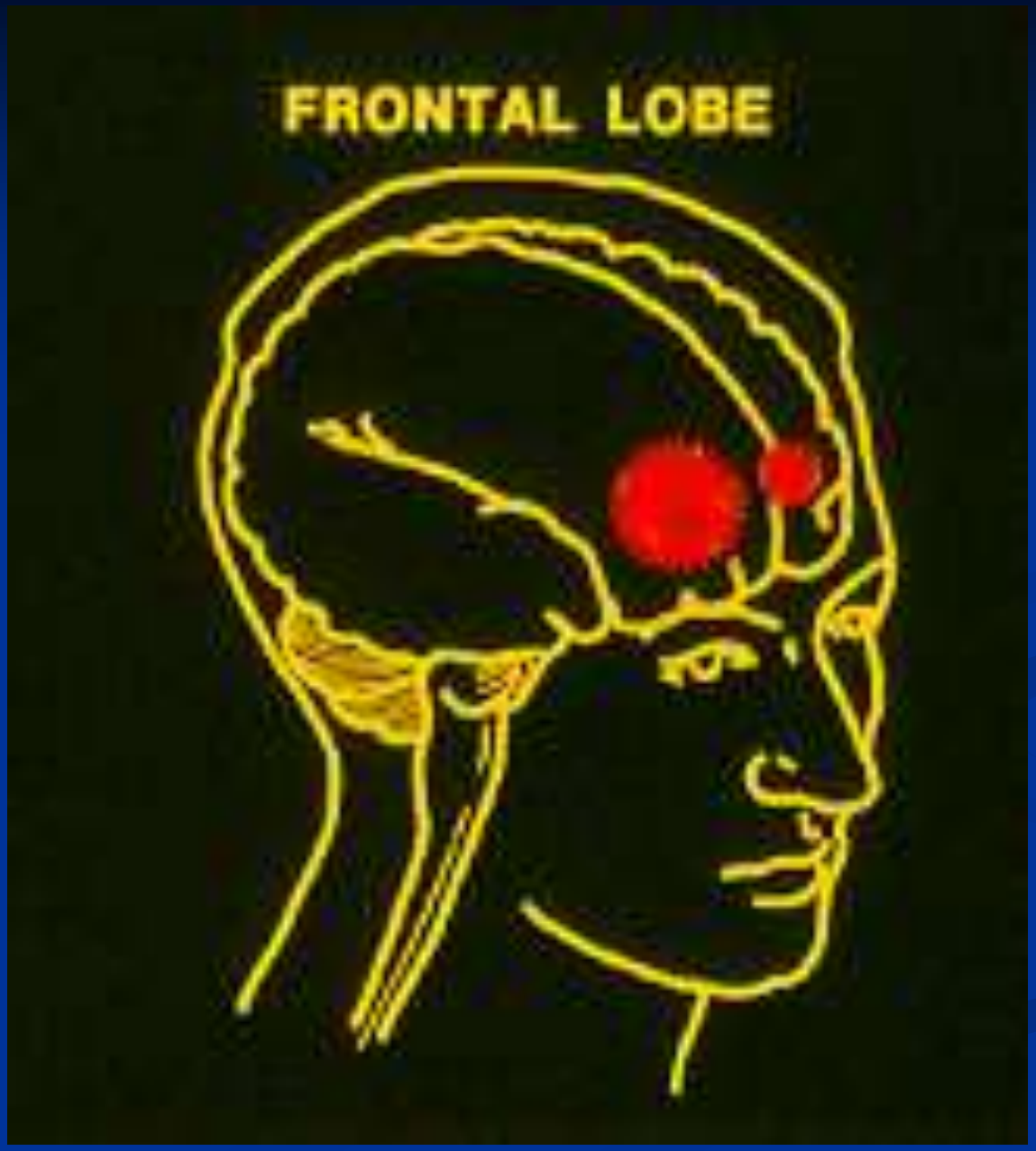
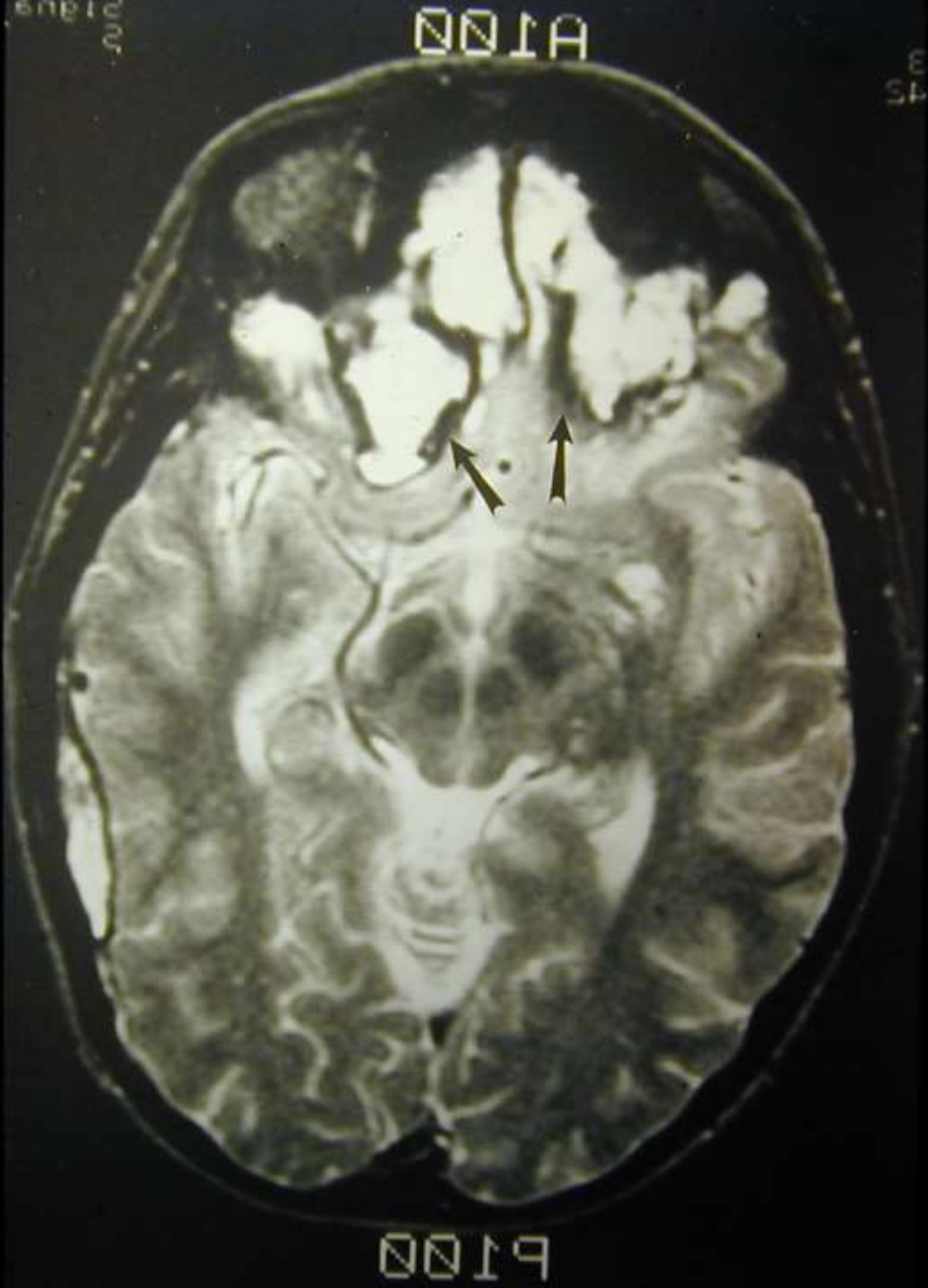

FRONTAL LOBE

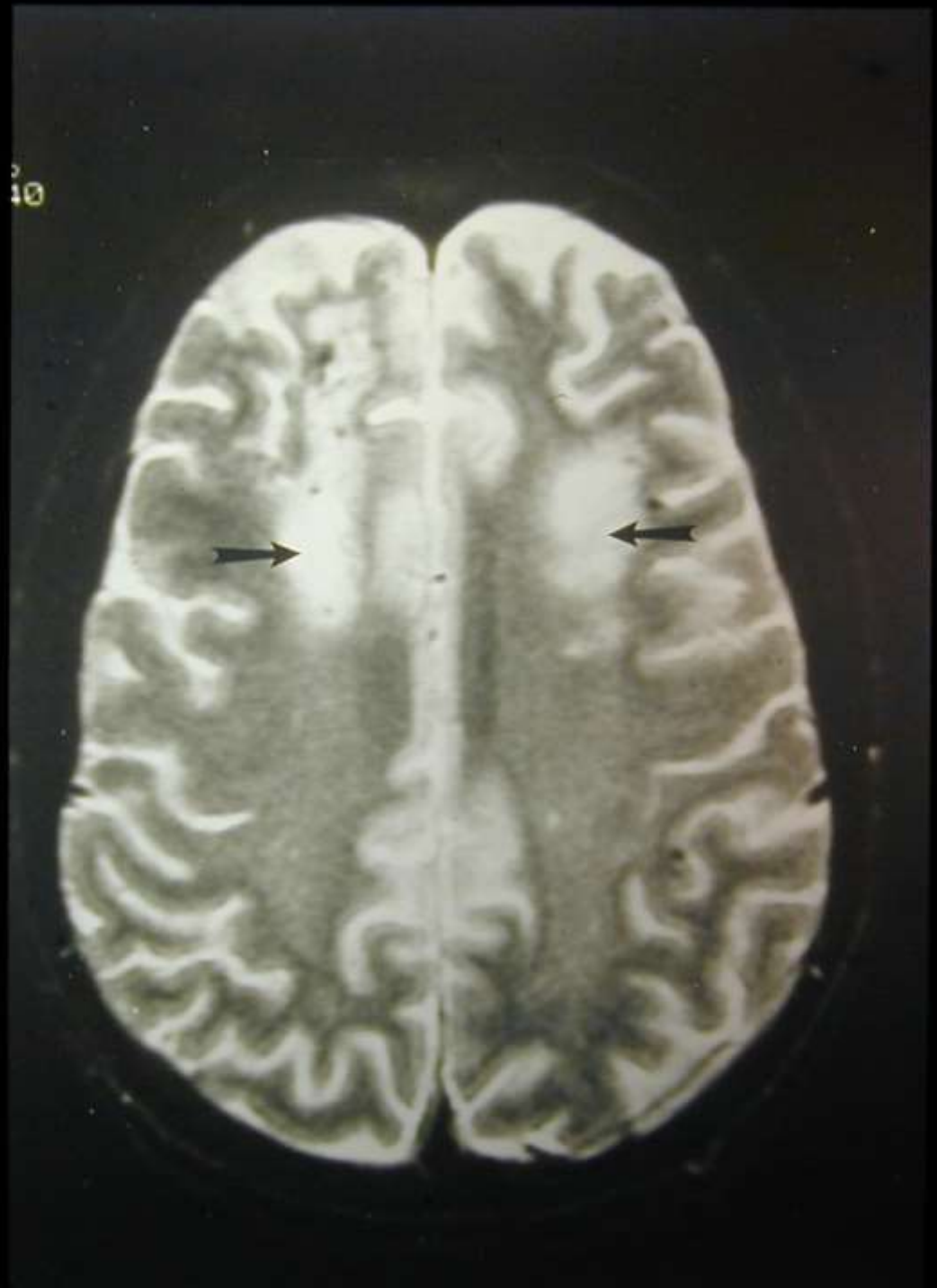

A100
P100

Case 2

Fall

Orbitofrontal

Bi temporal

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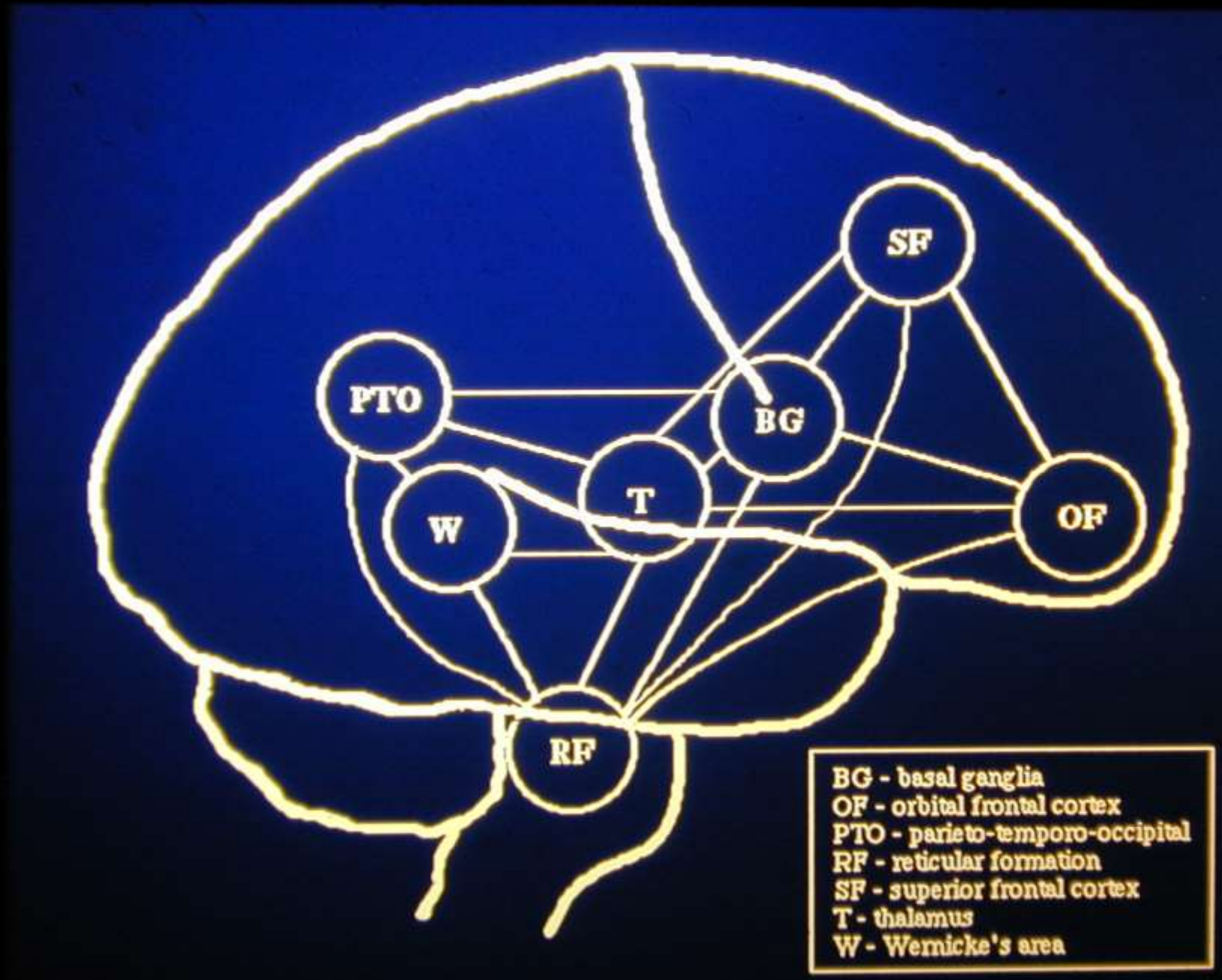
SF
PTO
BG
T
W
OF
RF
BG - basal ganglia
OF - orbital frontal cortex
PTO - parieto-temporo-occipital
RF - reticular formation
SF - superior frontal cortex
T - thalamus
W - Wernicke's area

CAUSE OF DISABILITY

- MENTAL > PHYSICAL

Common Neuro-Medical Sequelae

- Hydrocephalus
- Seizures
- Spasticity/dystonia
- Posttraumatic Movement Disorders
- Heterotopic Ossification
- Communicative, cognitive and behavioral disturbances


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E:22/Fr
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I120

Ventricular Shunting

- Hydrocephalus vs. Atrophy
- Risk Benefit Ratio (complications/outcome)
- Timing
- Type of Shunt Valve (programmable)
- Rehabilitation Synergy (therapy/medications)
- Long term management

SEIZURES

- Risk/benefit considerations
- Provide “functional” control without side-effects.

NEW ANTI-EPILEPTIC DRUGS

- Levaracitam
- Lamotrigine
- Felbamate
- Tiagabine
- Topiramate
- Vigabatrin
- Others…….

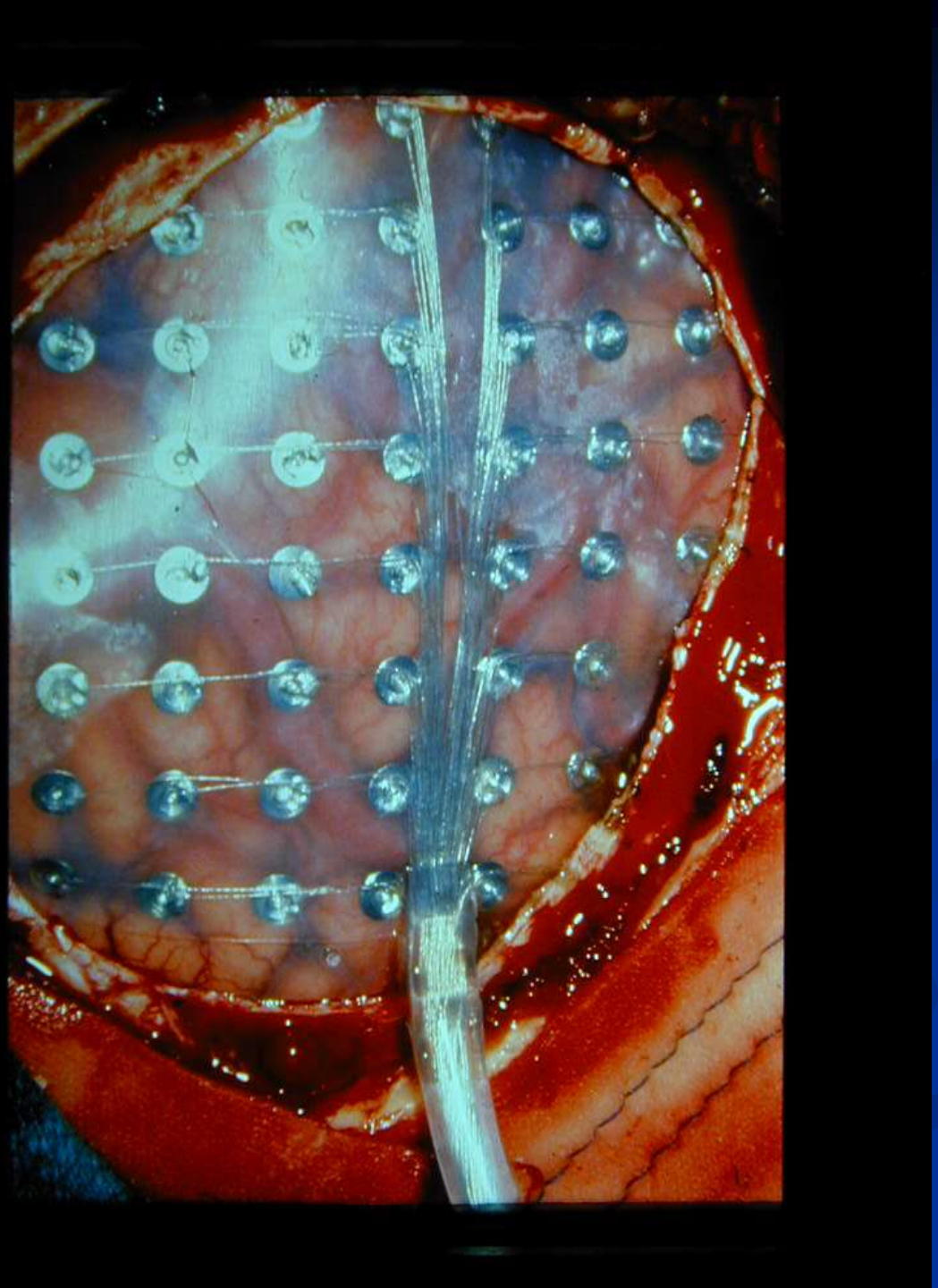
REFRACTIVE CONSIDERATIONS

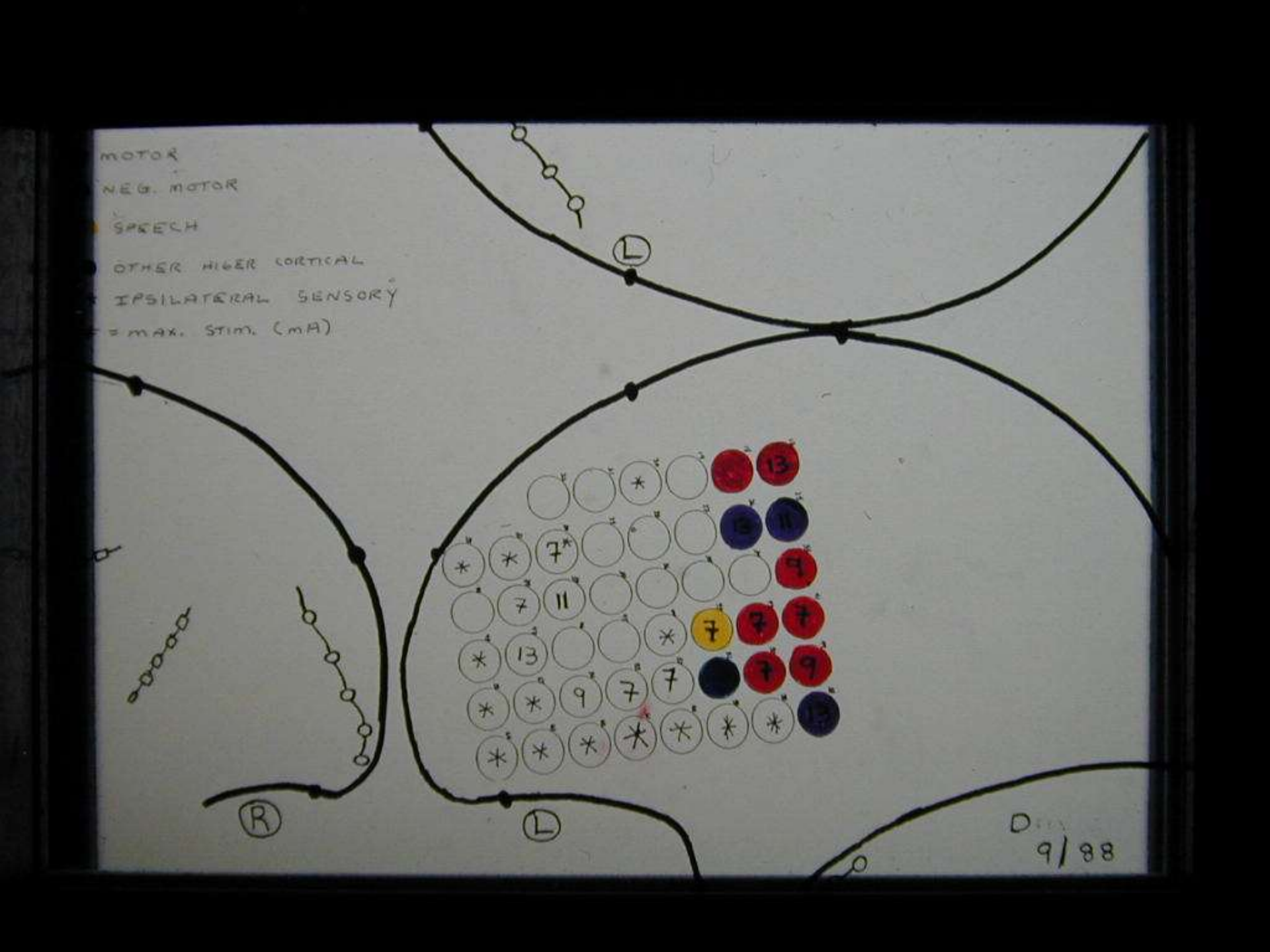
- Electrophysiologic and Imaging Workup
- Surgical Options
- Vagus Nerve Stimulators
- Genetic Research – "Inherited Epilepsies"

The NCP System: Implanted Components

TYPES OF SURGERY

- Temporal lobectomy
- Extratemporal resections
- Corpus callosotomy
- Stereotaxic procedures
- Hemispherectomy




MOTOR
NEG. MOTOR
SPEECH
OTHER HIGER CORTICAL
IPSILATERAL SENSORY
= MAX. STIM. (mA)
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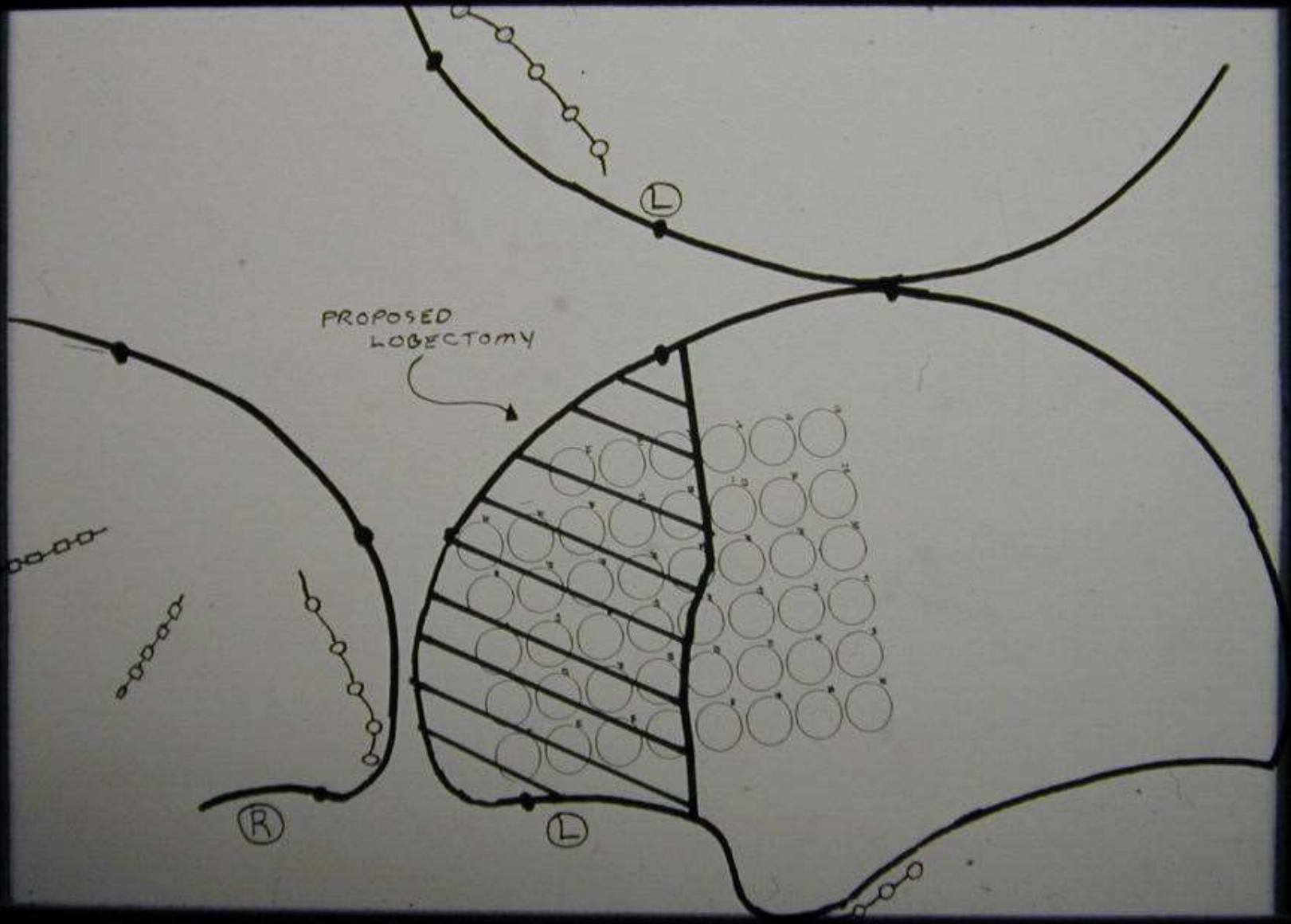
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LOBECTOMY
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SPASTICITY

- Dantrolene Sodium
- Lioresal
- Diazepam
- Tizanidine
- Clonidine
- Klonopin

SPASTICITY – ADJUNCTIVE PROCEDURES

- Local and Regional Anesthetic Blocks *
- Phenol Neurolysis *
- Botox Type A Injection Therapy *

* Coupled with Rehabilitative Techniques

SPASTICITY – ADJUNCTIVE PROCEDURES

- Intrathecal Lioresal Pump
- Central Neurosurgical Intervention
- Functional Orthopedic Interventions

Intrathecal Baclofen (ITB) Therapy: Before and After Treatment

POSTTRAUMATIC MOVEMENT DISORDERS

- Akinetic or Hypokinetic – Parkinsonian
- Hyperkinetic
  - Tremors
  - Ataxia
  - Myoclonus
  - Dyskinesias
  - Dystonias

NEUROPHYSIOLOGIC CORRELATES OF MOVEMENT DICTATE "RATIONAL" TREATMENT

- AEDs
- Anti-Anxiety
- Parkinsonian Meds

POSTTRAUMATIC MOVEMENT DISORDERS

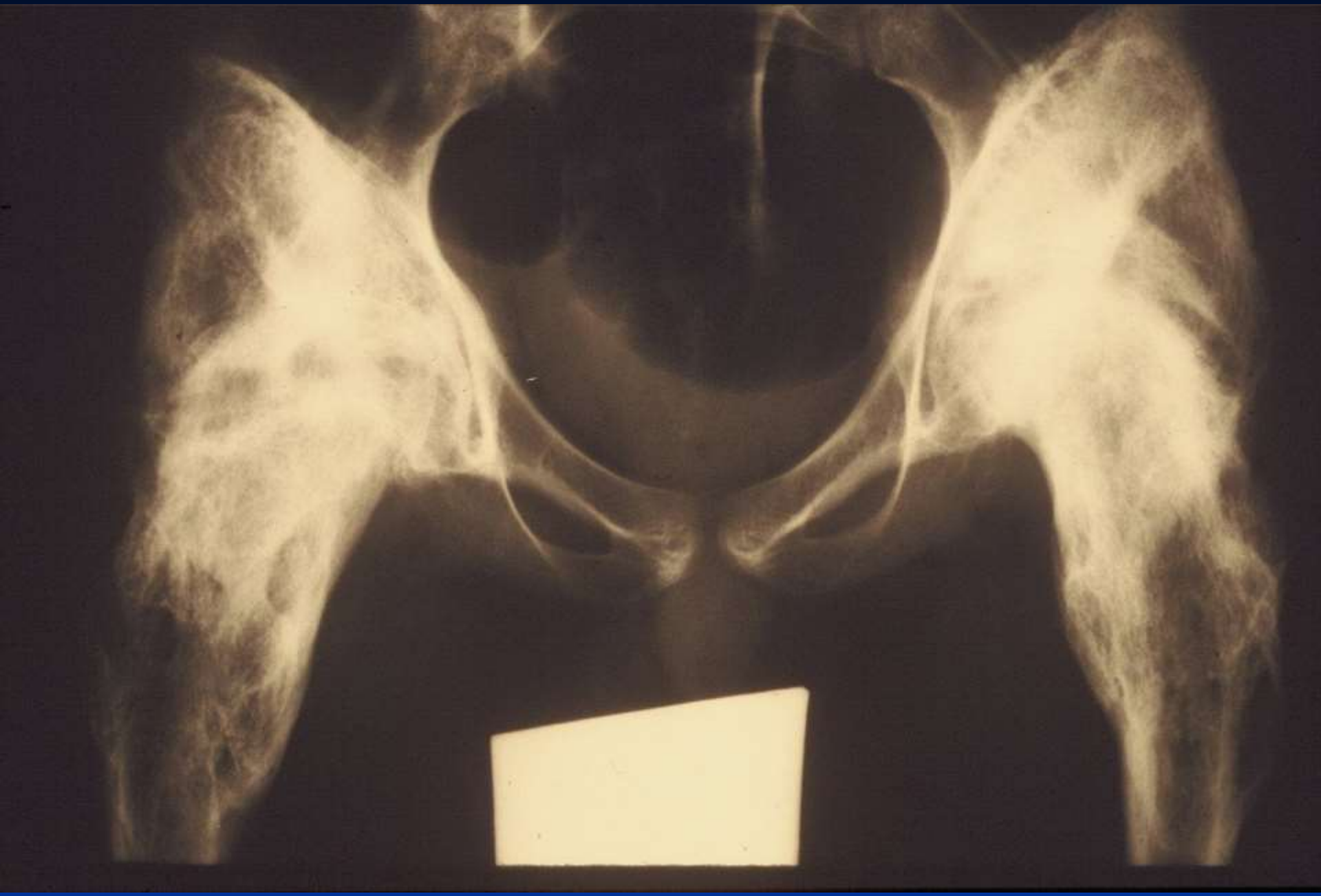
- Parkinson's research
- Essential Tremor Research

Deep Brain Thalamic Stimulator


TREMOR
Deep Brain
Thalamic Stimulator

HETEROTOPIC OSSIFICATION

- Non-Steroidal Anti-Inflammatories
- Diphosphonates (Didronel)
- Radiation Therapy
- Surgical Excision

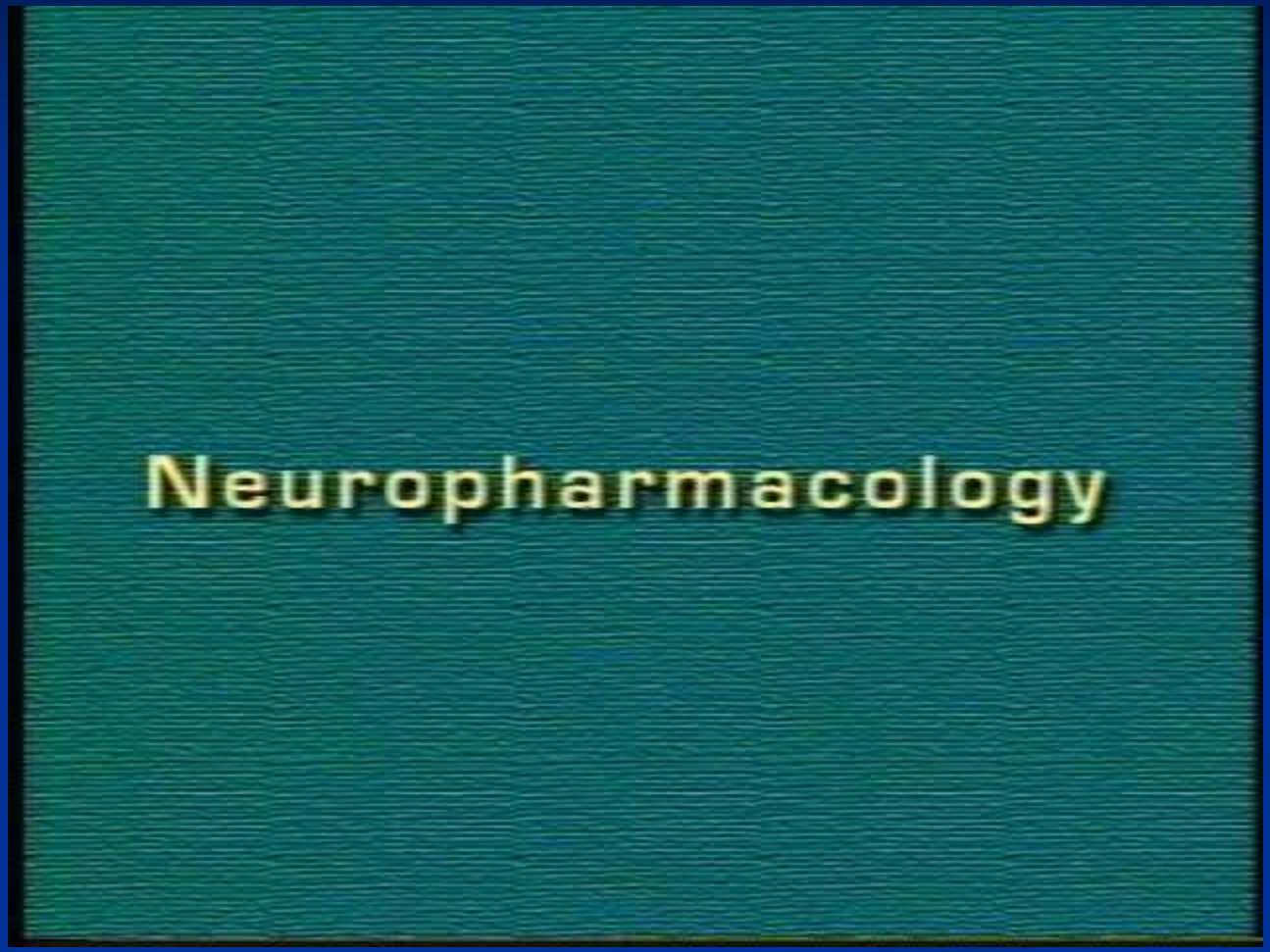


COGNITIVE-BEHAVIORAL DISTURBANCES

- Minimal Responsive
- Agitated – Aggressive
- Initiation and Communication
- Memory and Cognition
- Mood

NEUROTRANSMITTER IMBALANCES

- Acute
- Subacute
- Chronic

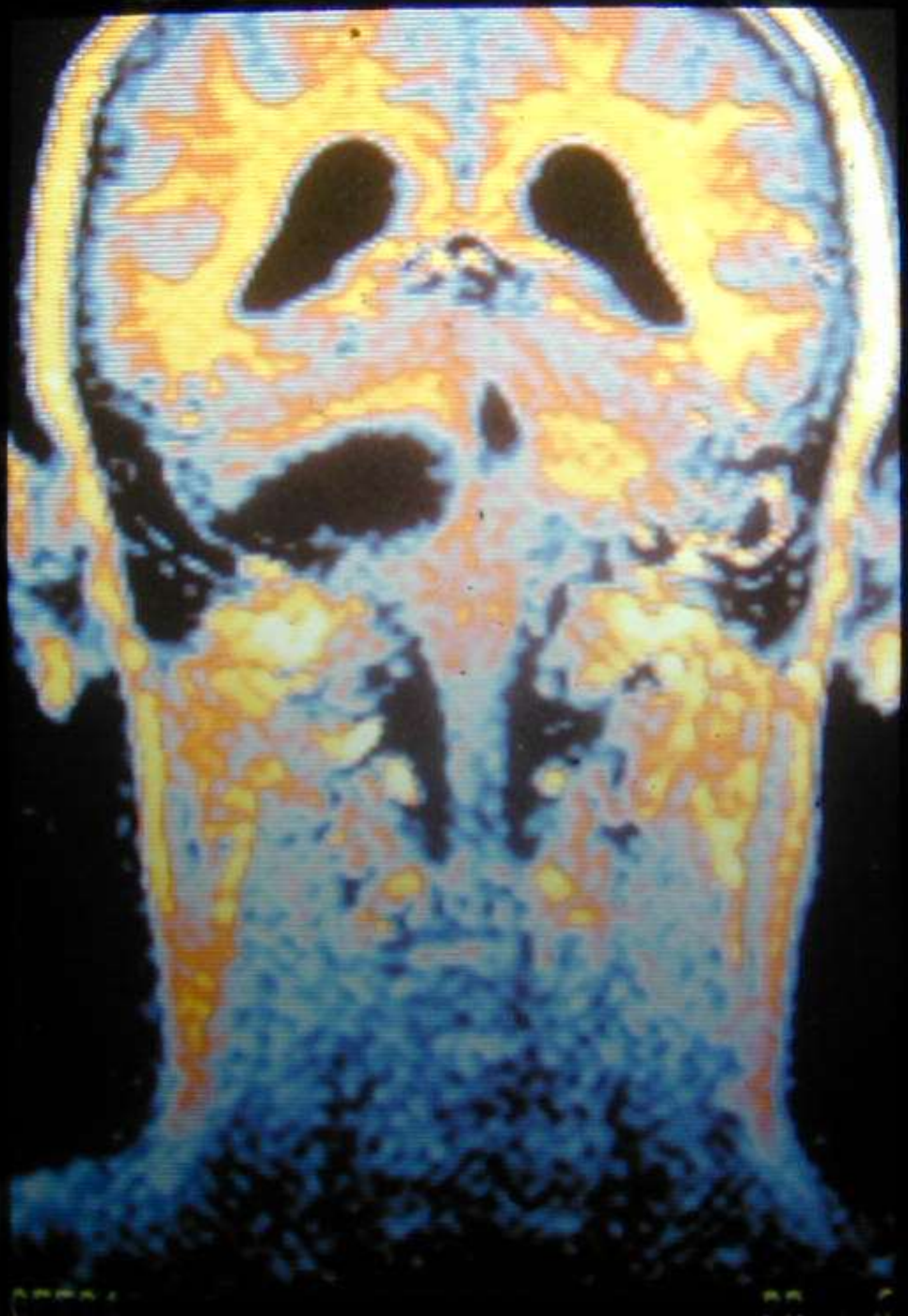

Neuropharmacology

MEMORY AND COGNITIVE DISORDERS

- Acetylcholine Enhancers (Alzheimer's' Meds)
- Vitamins (Lecithin, Phosphatidylcholine)
- Nootropes (Piracetam, Pramiracetam)

MOOD DISORDERS

- Tricyclic Antidepressants
- Novel Antidepressants
- Mood Stabilizers – AEDs (VPA, CBZ)
- Lithium
- Anxiolytics
- Neuroleptics



NEUROFUNCITONAL FUTURE CONSIDERATIONS

- HBO – acute vs. chronic
- Neural transplantation research
- Gene therapy

HYPERBARIC OXYGEN THERAPY (HBO)

- Carbon Monoxide
- Hypoxic – ischemic encephalopathy
- Traumatic focal and/or diffuse axonal injury

NEURAL TRANSPLANTATION

- Parkinson's and Huntington's research
- Embryonic neural tissue grafting
  - replacement of damaged nerve cells
  - re-establishment of neural pathways
  - release of specific neurotransmitters
  - production of factors which promote neural growth

versity of Pittsburgh
ologist carefully
es a vial containing
lls that will be
d into stroke
t Alma Cerasini.

Stroke Rescue

an cells injected into the brain reverse paralysis?

By KATHLEEN FACKELMANN

HOLISTIC APPROACHES

Evidence Based Guidelines?

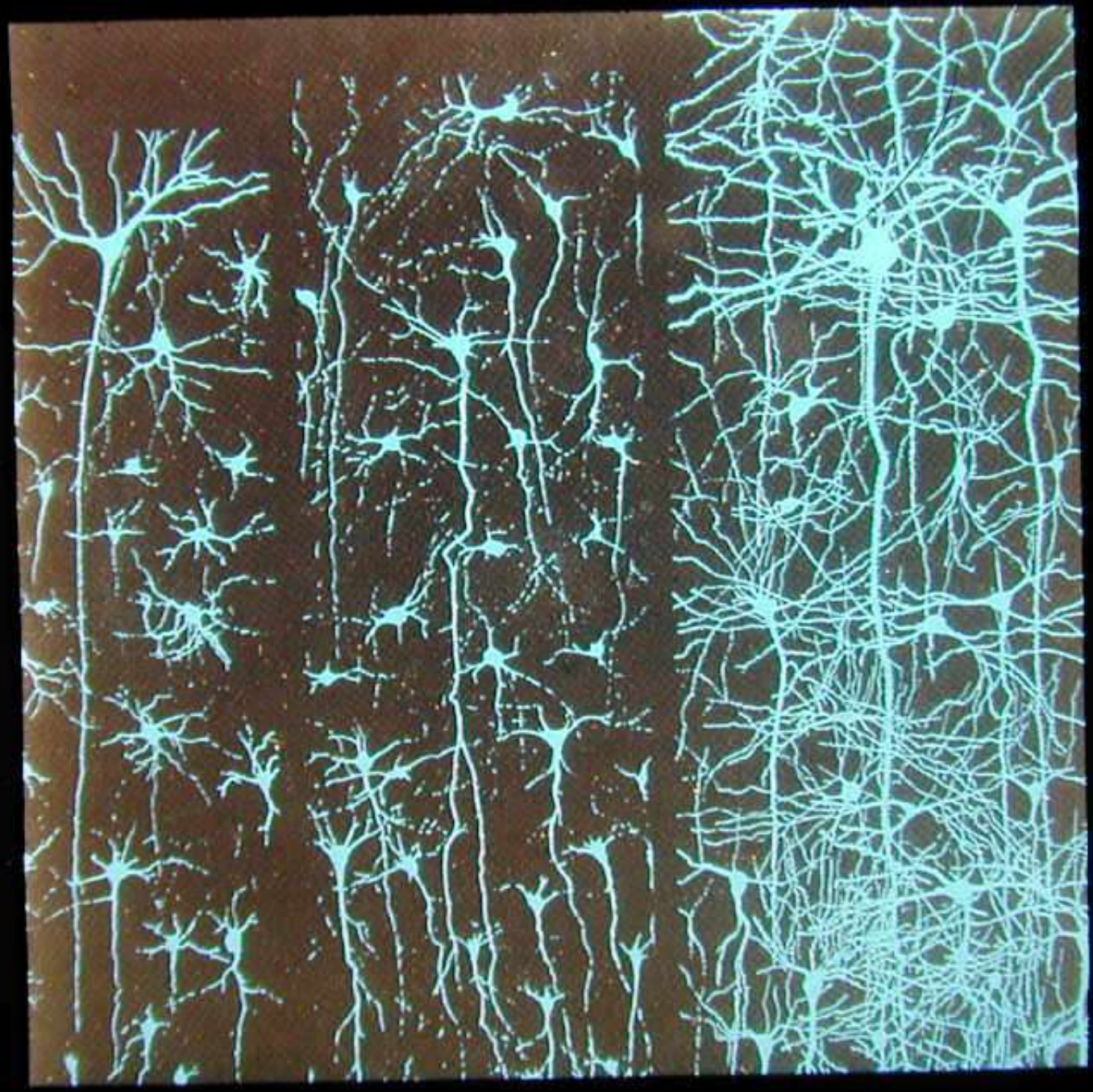
HOLISTIC APPROACHES

- Herbs
- Vitamins
- Diet
- Sport Supplements
- Procedures, i.e., acupuncture, therapeutic touch techniques, CST, etc.

Pharmacological Modulation of Plasticity in the Human Motor Cortex

Ziemann U,Meintzschel F, etal.

Neurorehab and Neural Repair
20(2)2006



AGING CONSIDERATIONS

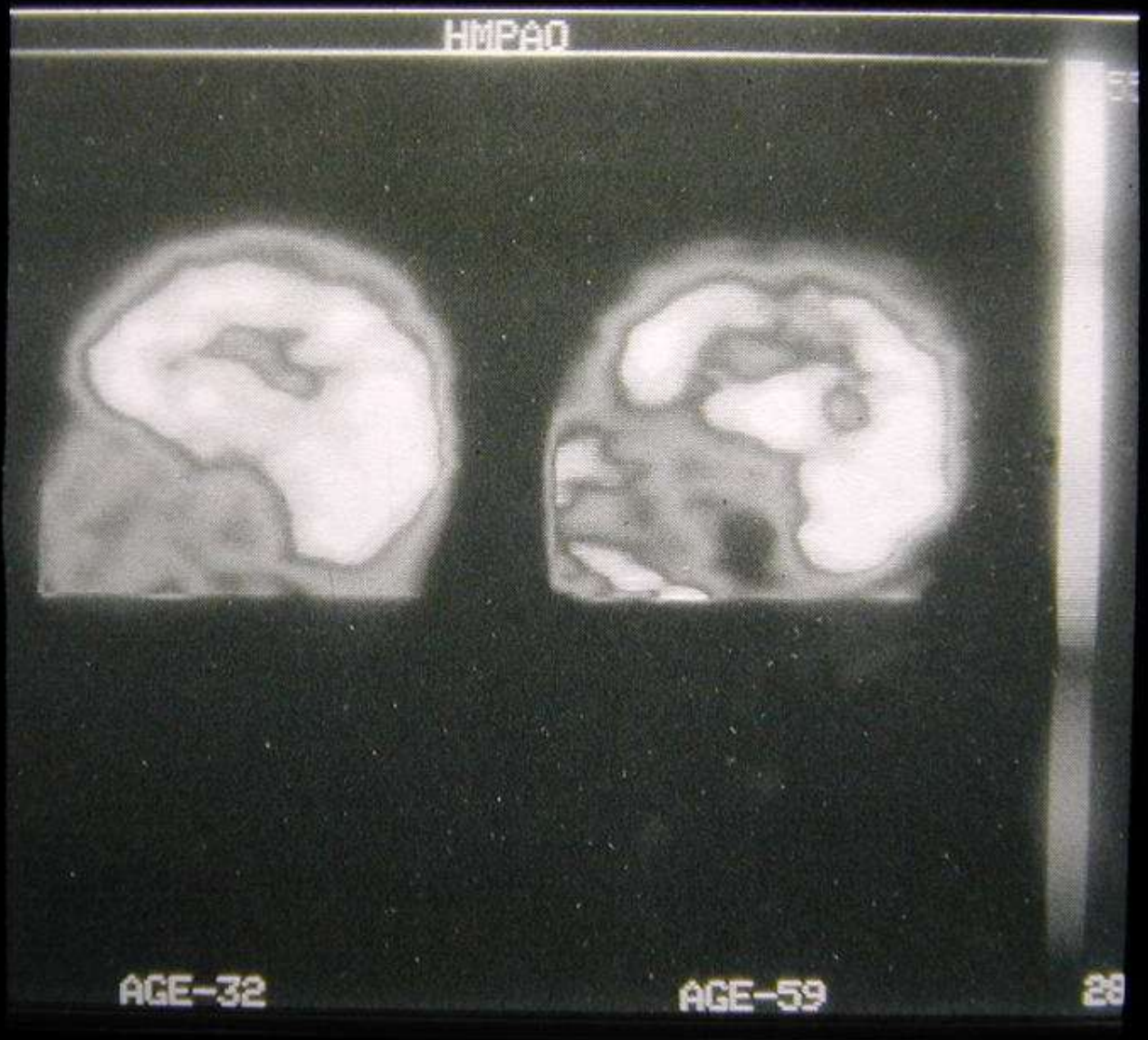
- Normal Aging
- Dementia – Alzheimer's
- Psychosocial dilemmas

toradiology (1998) 40: 428–434
pringer Verlag 1998

DIAGNOSTIC NEURORADIOLOGY

Krausz
Bonne
Gorfine
Karger
Lerer
Thisin

Age-related changes in brain perfusion of normal subjects detected by ^{99m}Tc-HMPAO SPECT

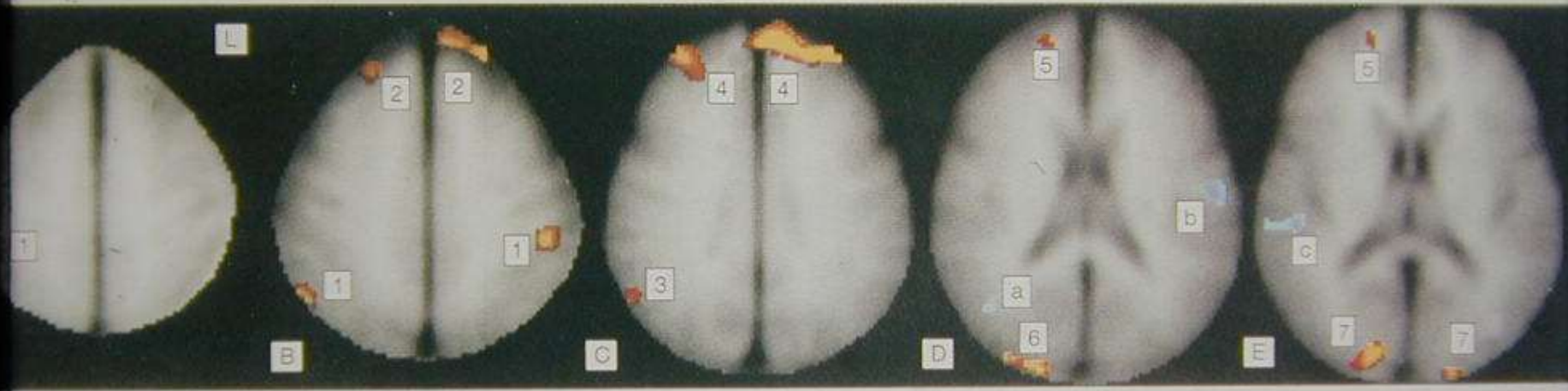

HMPAO
AGE-32
AGE-59

Effect of Estrogen on Brain Activation Patterns in Postmenopausal Women During Working Memory Tasks

Shaywitz, MD, et al.

JAMA, April 7, 1999

e 2. Functional Magnetic Resonance Imaging Showing Effect of Estrogen on the Verbal Storage Component of Verbal Working Memory



en was associated with increased activation of the anterior, frontal lobe regions (superior [regions 2 and 4] and middle [region 5] frontal gyri) bilaterally. Of th
or regions, estrogen was associated with increased activation of the inferior parietal lobule bilaterally (regions 1 and 3); and the superior (region 6) and midd
7) occipital gyri on the right. Sites with decreased activation on estrogen included regions around the inferior parietal lobule, as indicated by letter a, the le
sulcus, as indicated by letter b, and the right superior temporal gyrus, as indicated by letter c. Letters under each image correspond to the following positio
he z-axis of the Talairach atlas. A indicates 50; B, 40; C, 32; D, 24; and E, 12.

DETERMINANTS OF OUTCOME

- Pre-injury Personality Characteristics
- Type and Severity Neurologic Injury
- Support System Available

"It is not only the kind of injury that matters, but also the kind of head."

Sir Charles Symonds, 1937

LIFE ADAPTATION

Quality of Life and Outcome Considerations

WIT MODEL

Whatever **I**t **T**akes:

A Model for Community-Based Services

Willer, B., Corrigan, J.D., Brain Injury 8:7 1994, 647-659

"To be all within one's abilities"

- Relationships
- Productivity
- Socialization

Pathways and Planning Outcome Oriented Treatment.

"*I Skate to where the puck will be*"
-Wayne Gretsky

AWARENESS AND ACCESS

- Surveillance research
- TBI Model Systems 5 ⟶ 17 centers
- TBI Act 1995
  - Federal Initiatives
  - State Demonstration Grants
  - NIH Guidelines
- Information and dissemination
  - World Wide Web - Internet